



ENVIRONMENTAL ASSESSEMENT

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ENVIRONMENTAL ASSESSEMENT APPROVAL MEMO

PURPOSE AND SCOPE OF THE ENVIRONMENTAL SCOPING STATEMENT

A Positive Threshold Decision was made by the Bureau Environmental Officer for some or all elements of the Colombia Artisanal Gold Mining (Oro Legal), under the referenced IEE which were further considered in the referenced Scoping Statement (SS). The purpose of the Environmental Assessment is to provide Agency and host country decision-makers with a full discussion of significant environmental effects of a proposed action. It includes alternatives which would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of development objectives can be weighed against any adverse impacts upon the human environment or any irreversible or irretrievable commitment of resources.

In the past decade, Colombia has faced significant challenges in the development of its mining resources, particularly gold. The gold sector is complex. On the one hand, it represents significant wealth and development potential. On the other, it is characterized by high levels of informality, illegality and criminality. Colombia produces approximately 50 tons of legal gold per year on average. This represents just 10% of production, with 90% being produced illegally, typically by small, informal mining production units (MPUs) operating without permission, within the mining titles held by others. Three quarters of Colombian gold is produced within the departments of Antioquia and Chocó. Most small mines are characterized by poor safety and occupational health practices, which give rise to dangerous working conditions. Workers rarely receive state-mandated social security benefits, but economic alternatives are in short supply and are typically more poorly remunerated than mining. The most visible impact of the lack of formality/legality in the sector is the enormous amount of environmental damage generated; degradation of large swathes of land, pollution of water sources and mercury contamination.

The United States Agency for International Development (USAID)-financed “Colombia Artisanal Gold Mining – Environmental Impact Reduction Activity” (Oro Legal) seeks to address these issues. It is designed to promote more responsible practices within the Colombian artisanal gold mining sector (ASM), rehabilitating land degraded by mining, developing income diversification options for those who cannot or should not be involved in mining, protecting water sources in mining areas and reducing/eliminating the use of mercury. Oro Legal is a five-year, almost US\$ 20 million activity, ending in September 2020, which works closely with the Colombian public and private sectors. It was developed by USAID following the successful implementation of a mining component within the earlier, USAID-financed BioREDD+ Program.

Although Oro Legal is by design an activity intended to mitigate the environmental impact of the artisanal gold mining sector in Colombia, USAID regulations require that an environmental assessment (EA) be undertaken. The EA was conducted in accord with the guidelines set out in Title 22 of the Code of Federal Regulations (CFR) 216.6 (c), whereby alternatives are developed and compared in response to “significant issues” identified in Oro Legal’s Scoping Statement (SS). The EA addresses possible direct, indirect and cumulative effects on the environment arising from Oro Legal’s activities. Oro Legal is expected to undertake its activities in 22 municipalities in Antioquia and Chocó, These two departments account for almost 75% of the gold mined in Colombia.

In summary, the first alternative (A) consists of taking no action. The second (B), presents a series of actions currently proposed under Oro Legal. The third alternative (C) extends the scope of Alternative B to include additional activities that could theoretically be contemplated. The EA determined that the alternative which best responds to the significant issues identified and is considered feasible given the budget and duration of Oro Legal, is a hybrid of Alternative B, combined with several items of Alternative C. This can be considered “Alternative B+”. The EA provides an action plan that includes mitigation measures for potential impacts arising from activities implemented by Oro Legal, as well as monitoring indicators and methods.

BUREAU ENVIRONMENTAL OFFICERS FINDINGS AND SPECIFIED CONDITIONS OF APPROVAL

The EA appropriately provides a detailed study of the reasonable foreseeable environmental impacts, both positive and negative, of the proposed actions financed by USAID/Colombia and implemented by Oro Legal. This includes alternatives that: (i) prevent, minimize and/or mitigate adverse effects, and (ii) enhance the environmental quality of the expected benefits arising from the Activity as weighed against any adverse impacts to humans or the environment, or irreversible impacts to natural resources. Likewise, it analyses Oro Legal’s direct, indirect and cumulative effects on the environment.

No additional considerations need to be addressed in the EA.

INTERNAL CLEARANCE PAGE FOR

Environmental Assessment USAID/Colombia Artisanal Gold Mining (Oro Legal)

FINAL VERSION

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USAID Colombia Artisanal Gold Mining -
Environmental Impact Reduction Activity
(Oro Legal)

ENVIRONMENTAL ASSESSMENT

AWARD: AID-514-C-15-00003

Environmental Assessment

AWARD: AID-514-C-15-00003

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Implemented by: Chemonics International Inc.

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ACRONYMS

AMAP/UNEP	Technical Background Report for the Global Mercury Assessment
ANLA	National Environmental Licensing Agency
ANM	National Mining Agency
ASM	Artisanal and Small Mining
BEO	Bureau Environmental Officer
BioREDD+	USAID/Colombia Biodiversity – Reduced Emissions from Deforestation and Forest Degradation Program
CAR	Regional Environmental Authority
CC	Community Council
CFR	Code of Federal Regulations
CDCS	Country Development and Cooperation Strategy
CODECHOCÓ	Regional Environmental Authority in the Department of Chocó
CORANTIOQUIA	Regional Environmental Authority in the Department of Antioquia
CORNARE	Regional Environmental Authority of the Negro and Nare River Basins
DO	Development Objective
DOC	Dissolved organic carbon
DOM	Dissolved organic matter
EA	Environmental Assessment
EMA	Environmental Mitigation Approach
GOC	Government of Colombia
IEE	Initial Environmental Examination
IIAP	Institute of Pacific Environmental Research

IWRM	Integrated Water Resource Management
LEDs	Low Emissions Development Strategy
MME	Ministry of Mines and Energy
MADS	Ministry of Environment and Sustainable Development
MPU	Mining Production Unit
MOU	Memorandum of Understanding
NAMA	Nationally Appropriate Mitigation Action
NMA	National Mining Agency
PMA	Environmental Management Plans
PMP	Performance Management Plan
PTO	Operations & Work Plans
REDD+	Reducing Emissions from Deforestation and Forest Degradation
UNM	Universidad Nacional Sede Medellín
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
SENA	National Training Service of Colombia
SS	Scoping Statement
TA	Technical Assistance
WHO	World Health Organization

EXECUTIVE SUMMARY

In the past decade, Colombia has faced significant challenges in the development of its mining resources, particularly gold. The gold sector is complex. On the one hand, it represents significant wealth and development potential. On the other, it is characterized by high levels of informality, illegality and criminality. Colombia produces approximately 50 tons of legal gold per year on average. This represents just 10% of production, with 90% being produced illegally, typically by small, informal mining production units (MPUs) operating without permission, within the mining titles held by others. Three quarters of Colombian gold is produced within the departments of Antioquia and Chocó. Most small mines are characterized by poor safety and occupational health practices, which give rise to dangerous working conditions. Workers rarely receive state-mandated social security benefits, but economic alternatives are in short supply and are typically more poorly remunerated than mining. The most visible impact of the lack of formality/legality in the sector is the enormous amount of environmental damage generated; degradation of large swathes of land, pollution of water sources and mercury contamination.

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Although Oro Legal is by design an activity intended to mitigate the environmental impact of the artisanal gold mining sector in Colombia, USAID regulations require that an environmental assessment (EA) be undertaken. The EA is presented here. It was conducted in accord with the guidelines set out in Title 22 of the Code of Federal Regulations (CFR) 216.6 (c), whereby alternatives are developed and compared in response to “significant issues” identified in Oro Legal’s Scoping Statement (SS). The EA addresses possible direct, indirect and cumulative effects on the environment arising from Oro Legal’s activities. It should be noted that the focus of the EA is Oro Legal-supported activities within the Colombian gold mining sector and NOT the environmental impact of the gold mining sector itself. This distinction is an important one to bear in mind when reading the rest of the document.

In summary, the first alternative (A) consists of taking no action. The second (B), presents a series of actions currently proposed under Oro Legal. The third alternative (C) extends the scope of Alternative B to include additional activities that could theoretically be contemplated. The EA determined that the alternative which best responds to the significant

issues identified and is considered feasible given the budget and duration of Oro Legal, is a hybrid of Alternative B, combined with several items of Alternative C. This can be considered “Alternative B+”. The EA provides an action plan that includes mitigation measures for potential impacts arising from activities implemented by Oro Legal, as well as monitoring indicators and methods.

I. INTRODUCTION

Colombia has a long history of gold mining. Well before the arrival of Spanish conquerors, indigenous populations were mining gold and, under the Spanish regime, gold was seen as an important source of revenue. In recent times, mining has attracted public attention given its social, environmental and economic impact; not always positive. Since the price of gold began to increase significantly during 2010, a gold rush started in Colombia. Gold prices rose from nearly \$1000/oz. in 2009, to a peak of \$1900/oz. in 2012. Consequently, gold mining in Colombia has increased by over 300% since 2006.

The scale of mining has grown faster than the institutional capacity of the Colombian government (GOC) to adequately control mining activities. The lack of an adequate institutional framework to support mining operations is reflected in several ways. The environmental and health impacts of unauthorized mining activities are seen mainly in poor water quality for human consumption, air and soil pollution from heavy metals, deforestation, and soil degradation.

Environmental deterioration is exacerbated by the illegality and informality of the activity. The lack of land titles, the complexity involved in obtaining mining rights, and the investment uncertainties in the ASM sector further contribute to environmental degradation, with illegal operations leaving behind extensive environmental impacts (*pasivos ambientales*) for which no one is held legally responsible for costly environmental/site rehabilitation. More generally, illegal gold mining also promotes localized deforestation and biodiversity loss. The illegal nature of many ASM operations means that the government loses significant tax and royalty revenues. As a result, most mining regions have not seen the expected improvements in social infrastructure, health or education.

Legalization and formalization have significant positive impacts on the environment. Once existing legislation and regulations are enforced, ASM operations will use less mercury or no mercury at all (Colombia has passed legislation banning the use of mercury by 2018), and must implement an environmental management plan to avoid or mitigate negative environmental impacts. Formalizing ASM operations will also contribute to consolidating the peace process in Colombia since illegal mining has fueled conflict in some regions and generated social unrest. Illegal armed groups have used the lack of State control to create opportunities for money laundering, extortion and intimidation¹.

Oro Legal is well-aligned with USAID/Colombia's 2014 Country Development and Cooperation Strategy (CDCS) (<http://www.usaid.gov/documents/1862/country-developmentcooperation-strategy-2014-2018>), the overarching goal of which is to assist Colombia with the implementation of a sustainable and inclusive peace. Its development objectives are: (i) establish the effective presence of democratic institutions and processes in targeted areas; (ii) advance reconciliation among victims, ex-combatants and others; (iii)

¹ Contraloría General de la República, 2012.

improve conditions for inclusive, rural economic growth, and (iv) strengthen environmental resiliency and low emissions development.

The Oro Legal Results Framework in Figure 1 underpins the above outlined approach and feeds directly into the USAID Colombia Mission development hypothesis, contributing to Development Objective (DO) 4 and the Country Development Cooperation Strategy Goal: Colombia more capable of successfully implementing a sustainable and inclusive peace.

The results framework summarizes how each expected result will contribute to the achievement of Oro Legal's two objectives and USAID's broader country strategy. Objective 1 – "Build effective governance capacity in gold mining activities in target municipalities" – is largely about supporting more responsible mining through improved governance in the sector by government entities, the private sector, and ASM operators with an aim to reduce the use of mercury and prevent other environmental impacts through more effective application of mining regulations, legalization and formalization of artisanal and small operations, and promotion of non-mercury methods for refining gold. Objective 2 – "Increase the capacity of the Colombian government, community and private sector to address the environmental impacts caused by illegal mining" - focuses on remediation of the environmental legacy of decades of irresponsible mining, improvement of livelihoods through non-mining activities, and conservation of natural resources, in particular, water.

Figure I-1 Oro Legal Results Framework



Pursuant to the Initial Environmental Examination (IEE) for the USAID/Colombia Environmental Program (LAC-IEE-15-02, issued on September 26, 2014), a Positive Determination was issued for USAID Environment Program activities associated with the reduction of mercury use by small informal mining units and restoration of areas degraded by unauthorized mining activities, as these activities may cause significant environmental impacts. Consequently, an approved Scoping Statement and Environmental Assessment are required under the contract awarded to Chemonics International for the Oro Legal Activity.

The EA is a detailed study of the reasonably foreseeable environmental impacts, both positive and negative, of the proposed actions financed by USAID and implemented by Oro Legal. This includes alternatives that: (i) prevent, minimize and/or mitigate adverse effects, and (ii) enhance the environmental quality of the expected benefits arising from the Activity as weighed against any adverse impacts to humans or the environment, or irreversible

impacts to natural resources. Likewise, it analyses Oro Legal's direct, indirect and cumulative effects on the environment.

The present EA includes the following factors and issues:

1. Potential environmental impacts of the activities proposed by Oro Legal during a five-year implementation period.
2. Opinions of key stakeholders regarding activities proposed by Oro Legal, including national and regional government authorities, representatives of Afro Colombian Community Councils (CCs), producer and ASM associations, municipal authorities, private mining companies, and the Institute of Pacific Environmental Research (IIAP), among others.
3. Objective assessment of the three alternatives to determine how each addresses the significant issues identified in the SS.
4. Explanation as to why the "Recommended Alternative" was selected.
5. Presentation of a comprehensive management plan that includes mitigation measures for potential impacts and a monitoring plan.

2. BASELINE – EXISTING CONDITIONS

2.1 Legal Framework in Colombia covering ASM

The institutional and legal framework for the ASM sector in Colombia is complex in terms of the number of national, regional and local government entities involved in the mining sector. The legal and regulatory complexity of the mining sector in Colombia is illustrated by the following list that summarizes the most relevant laws, regulations and administrative instruments.²

Mining

- Decree 2636/1994 - Legalization of Informal Mining 1994.
- Law 685/2001 - Mining Code applicable in Colombia as of 2001.
- Decree 2390/2002 - Legalization of Informal Mining 2001.
- Decree 2653/2003 - Regulates Article 63 of Law 685/2001, appointing experts for determination of competing claims.
- Law 1382/2010 - Amends Mining Code Law 685. Declared unconstitutional in May 2013.
- Decree 2715/2010 - Legalization of Traditional Mining, 2010.
- Ruling C-366, Constitutional Court - Law 1382/2010. Declared unconstitutional.
- Decree 1970/2012 - Amends Decree 2715/2010.
- Decree 0933/2013 - Sets out provisions on the formalization of traditional mining and modified definitions from the Mining Glossary.
- Decree 480/2014 - Rules for mining formalization subcontracts.
- Resolution 9 0719/2014 - National policy for mining formalization.
- Resolution 256/2014 - Adoption of the National Mining Ordination Plan.
- Decree 1073/2015 - Unique regulatory decree for the mining and energy sectors.
- Decree 2504/2015 - Adds to decree 1073/2015 to define the technical, technological, operational and administrative aspects for mining audits and supervision.

Royalties

- Law 141/1995 - Royalty Law. Creates the National Royalties Fund and the National Royalties Commission.
- Law 756/2002 - Amendment of Law 141/1994.
- Decree 416/2007 – Regulates Law 756/2002 in relation to the destination and distribution of royalties and compensations, control and oversight mechanisms and corrective measures, among others.

Environmental

- Law 2/1959 - Establishes "Protected Forest Areas" and "Forests of General Interest" per the classification of Legislative Decree No. 2278/1953: Pacific Forest Reserve Area.

² Colombian Treasury Inspector's Office, 2013.

- Decree Law 2811/1974 - National Code of Renewable Natural Resources and Environmental Protection.
- Law 99/1993 - Creates the Ministry of Environment, reorganizes environmental management and conservation of renewable natural resources, and creates the National Environmental System (SINA in Spanish).
- Law 388/1997 - Territorial Development Law. Amends Law 9/1989 and Law 2/1991.
- Law 1333/2009 - Establishes punitive procedures for environmental infractions.
- Law 373/1997 - Establishes the program for the efficient use and conservation of water resources.
- Law 1021/2006 - Establishes the administrative organization and regulations for activities related to natural forests and forest plantations.
- Law 1252/2008 – Establishes environmental regulations for hazardous waste.
- Decree 2372/2010 - Regulates the National Protected Areas System and defines management categories for protected areas.
- Decree 2820/2010 – Regulates environmental licensing procedures.
- Resolution 918/2011 – Defines requirements and procedures for the withdrawal of areas in national and regional forest reserves for development that is considered in the public interest.
- Law 1658/2013 – Establishes how mercury is marketed and used in different industrial activities and develops incentives for reduction and elimination.
- Decree 2041/2014 – Regulates environmental licensing procedures.
- Resolution 1274/2014 – Modifies Resolution 1527/2012 for activities with minor environmental impact and public benefit in forest reserves without re-designation.
- Resolution 631/2015 – Establishes parameters and permissible limits for waste water discharge into bodies of water and public sewer systems.
- Decree 1076/2015 - Unique regulatory decree for the environment and sustainable development sector.
- Decree 2220/2015 – Amends Decree 1076/2015 to include environmental licenses and permits for National Interest and Strategic Projects.

Social

- Law 21/1991 - Approves ILO Convention 0169.
- Law 70/1993 - Policy for Afro-Colombian communities.
- Decree 1745/1995 – Regulates Law 70/1993 on procedures for the recognition of collective property rights for Afro-Colombian communities, among other provisions.
- Decree 2253/1998 – Regulates Law 70/1993 for the creation of the Commission of Studies for the formulation of development plans on Afro-Colombian territories.
- Decree 3050/2002 – Regulates the conformation, quorum, work sessions and function of the Commission of Studies for the formulation of development plans in Afro-Colombian territories. Amended by Decree 4007 of 2006, which eliminates the article regarding quorum, and modifies articles regarding conformation, sessions and function of the Commission of Studies.
- ILO Convention 169 - Convention on indigenous and tribal peoples as independent entities.

Law Enforcement

- Law 599/2000, Article 333 - Defines sanctions for negligent environmental contamination from the extraction of minerals and hydrocarbons.
- Law 1453/2011, Article 36 – Amends law 599 of 2010, and defines sanctions for environmental contamination related to mineral extraction and hydrocarbons.
- Decree 0079/2012 – Regulates Law 1453/2011 in relation to procedures for imposing sanctions.
- Convention 027/2007 - Interinstitutional agreement between the Ministry of Mines and Energy, the Ministry of the Environment, the Ministry of Housing and Territorial Development, and Ingeominas to develop strategies and join efforts to eradicate illegal mining.

National Development Plan

- Law 812/2003 - National Development Plan 2002 – 2006.
- Law 1151/2007 - National Development Plan 2006 – 2010.
- Law 1450/2011 - National Development Plan 2010 – 2014.
- Law 753/2015 – National Development Plan 2014 - 2018.

National Mining Development Plan

- National Mining Development Plan 2002 – 2006.
- National Mining Development Plan 2007 – 2010.
- National Mining Development Plan up to 2109.

2.2 Institutional Framework for the Oro Legal Activity

Implementation of the Oro Legal Activity will involve different public institutions. Among the most important are:

Ministry of Mines and Energy. The Ministry of Mines and Energy (MME) is charged with directing national policy with regard to mining, hydrocarbons and energy infrastructure in Colombia. It is responsible for managing the country's non-renewable resources to ensure the best use thereof (Ministry of Mines and Energy, 2014).

National Mining Agency. The National Mining Agency (ANM) is a technical entity that works to promote the mining sector based on transparency, efficiency, and with environmental and social responsibility to maximize the sector's contribution to inclusive, sustainable development of Colombia (National Mining Agency, 2014). Its duties include the management of State-owned mineral resources, granting titles and claims, and monitoring and control of mining activities.

Secretary of Mines, Antioquia Governor's Office. Unique³ among regional governments, the Secretary of Mines of the Antioquia Governor's Office designs, promotes and manages policies, plans, programs and projects for the economic and social development of the mining sector. This public entity is tasked with implementing departmental policies for the development of the mining sector by promoting and encouraging exploration and exploitation of mining resources, which is technically sound and socially acceptable. It has regulatory responsibilities delegated by the GOC in relation to the control and legalization of mining, and granting and monitoring mining titles. (Secretary of Mines, 2012).

Ministry of the Environment and Sustainable Development. The Ministry of the Environment and Sustainable Development (MADS) oversees management of the environment and renewable natural resources of Colombia. It is in charge of guiding and regulating all environmental matters, and defining policies and regulations regarding the restoration, conservation, protection, management, and sustainable use of renewable natural resources to ensure sustainable development (Ministry of the Environment and Sustainable Development, 2014).

CORANTIOQUIA and CODECHOCÓ. Like all Regional Autonomous Environmental Authorities (CARs), CORANTIOQUIA and CODECHOCÓ oversee the enforcement of environmental regulations and monitoring in the Departments of Antioquia⁴ and Chocó, respectively. The CARs are tasked with implementing policies, plans, programs and projects regarding the environment and renewable natural resources, as well as regulating their management and use in accordance with the regulations, standards and guidelines issued by the MADS.

Pacific Institute for Environmental Research. The Pacific Institute for Environmental Research (IIAP) coordinates, supports, and strengthens research capacity in the Pacific region (specifically the Chocó bio-geographic region) with the aim of improving human welfare in concert with conservation of the region's natural resource endowment and social and cultural values (IIAP, 2016). IIAP defines procedures and mechanisms to guarantee community participation in the decision-making process, respecting social and cultural contexts. Currently, IIAP works in three strategic areas: (i) ecosystems; (ii) production, and (iii) socio-cultural promotion. Its headquarters are located in Quibdó, Chocó, with offices in Tumaco, (Nariño), Buenaventura (Valle de Cauca) and Guapi (Cauca).

Afro-Colombian Community Councils. Community Councils (CC) are located mostly along the rivers on Colombia's Pacific coast. They were created by Law 70/1993 to govern and represent Afro-Colombian communities, who have constitutionally guaranteed rights over collectively held territories. The CCs define and allocate land uses within the collective territory, protect collective and members' rights, preserve the cultural identity of these groups, and preserve natural resources on collective lands.

³ It should be noted that the Chocó Governor's Office doesn't have a Secretary of Mines.

⁴ Three Regional Environmental Authorities (Corantioquia, Cornare and Corpouraba) have jurisdiction in the municipalities of the Department of Antioquia. Corantioquia has jurisdiction in nine of the prioritized municipalities and Cornare has jurisdiction in one prioritized municipality by legal Oro Legal.

2.3 Environmental and Socioeconomic Baseline Conditions

Oro Legal plans to conduct its activities in areas within the departments of Antioquia and Chocó⁵. The environmental and socioeconomic characterization of the areas of influence of Oro Legal is provided in Annex II.

⁵ Oro Legal's geographic intervention area can be expanded with authorization from USAID.

3. PURPOSE AND NEED

The purpose of this Environmental Assessment is: (i) to comply with the requirements of Title 22 CFR 216 and; (ii) to analyze the possible (positive and negative) environmental impacts arising from the proposed activities under the Oro Legal Activity.

There is a need to move informal and mostly illegal, small-scale gold mining in specific regions of Colombia towards a more environmentally and socially sustainable, formalized and legal state. The "need for action" for Oro Legal is aimed at reducing the environmental impacts of small-scale gold mining, with emphasis on eliminating the use of mercury and rehabilitating areas degraded by gold mining. The successful implementation of the Activity will result in improved, legally compliant MPUs in the target geographies. Oro Legal builds on the processes initiated and results achieved under the mining component of the USAID-funded BioREDD+ Program. Strong participation of the private sector is expected as well as involvement of relevant local, regional and national GOC counterparts. ASMs in selected municipalities of Antioquia and Chocó are the main target groups for Oro Legal.

The "desired future condition" of this activity is: (i) to build effective governance capacity for gold mining activities in target municipalities by strengthening public management functions and capacity building of local organizations with a stake in gold mining and (ii) to increase GOC, private sector and community capacity to address environmental degradation caused by illegal gold ASM operations, through improved water and air quality, rehabilitating degraded areas and developing income diversification options.

USAID/Colombia's development hypothesis underpinning the theory of change for Oro Legal is that if regional and local authorities are more effective in enforcing mining-related legislation and the right facilitating instruments (i.e. laws, regulations, policies, partnerships or projects) are in place to support environmental rehabilitation of degraded areas with the participation of land owners, the private sector and local communities, and subsequently regional and municipal authorities, will gain legitimacy and support, improving social, environmental and economic performance of ASM operations and advancing Colombia's peacebuilding goals (see Annexes I and 2).

The "desired future condition" under Objective I to build effective governance capacity in gold mining activities will be achieved by:

- Formal agreements with local, regional, and national government authorities.
- Support to the development and enforcement of the GOC legal and regulatory framework.
- Field inspections, follow-up, and monitoring by corresponding government authorities.
- Improve application of land use planning tools by local authorities to restrict certain types of contaminating activities in urban areas.
- Alliances between informal miners and large, formal mining companies.
- Strong, legal and responsible MPUs.

- Support to the preparation, approval and implementation of mining Operations and Work Plans (PTO) for ASM operations.
- Support to the preparation, approval and implementation of Environmental Management Plans (PMAs) for ASM operations.
- Enforcement of environmental, social, industrial safety and occupational health, tax and royalties regulations.
- ASM access to technical assistance and investment to implement gold mining technologies that reduce or eliminate mercury from the production cycle while maintaining or increasing gold recovery.
- Effective, continuous monitoring of: (i) airborne mercury emissions in key municipalities; (ii) liquid mercury use and recovery in a sample of 25 gold shops, and (iii) mercury mass balances in 25 MPUs.
- Monitoring of cyanide and other heavy metals in any gold processing centers that are recipients of direct support from Oro Legal.

The "desired future condition" under Objective 2 to address the environmental degradation caused by illegal ASM operations will be achieved by:

- Re-contouring lands degraded by informal and illegal gold mining.
- Reforesting degraded areas with commercial forest plantations (Antioquia).
- Restoration of degraded areas by natural/assisted regeneration (Chocó).
- Adequate silvicultural practices applied to plantations and natural regeneration on rehabilitated sites.
- Generation of mid to long term economic benefits linked to rehabilitation practices.
- Future benefits from plantations accruing to landowners, community and mining organizations, etc.
- Legalization of land titles.
- Rural income diversification options for miners that cannot become legalized.
- Honey production and other productive activities associated with tree plantations that generate income for former small miners and other rural families (Antioquia).
- Annatto production, processing and marketing activities to provide income alternatives to mining and to underpin rehabilitation and forest conservation and management agreements (Chocó).
- Significant public/private sector co-investment in rehabilitation activities and alternative value chains.
- Secure title and land tenure in degraded areas to be rehabilitated and water catchments that supply water to communities in mining areas.
- A social and political environment that supports investment in water catchment management and improvement of water supply systems.
- Monitoring of basic water quality parameters (in accordance with Colombian legislation, IRCA) in public water system improvement pilots that are recipients of direct support from Oro Legal.

4. PROPOSED ACTION

Gold mined illegally in the departments of Chocó and Antioquia will be reduced using the different available options - public or private - for legalization and formalization. This formalization effort will go hand-in-hand with a reduction in the amount of mercury used per unit of gold mined, and a decrease in the number of hectares identified as having environmental legacy or “pasivo ambiental” issues. ASM operations that are not able to become legal will receive support in finding new economic opportunities, particularly in the forestry and agricultural sectors (see objective 2 below for more detail).

Oro Legal maintains a position of neutrality regarding gold mining. The aim of Oro Legal is not to promote or condemn mining operations, rather it aims to support more responsible ASM activities wherever it is feasible to do so. It does this principally by legalizing/formalizing MPUs and by rehabilitating degraded areas, building on the successful approaches and lessons learned during the implementation of the BioREDD+/Mining component. (<http://www.bioredd.org/?q=biblioredd>). Oro Legal is a five-year project with a budget of approximately US\$20 million. To achieve its goal, expected results are organized under two objectives, as follows.

4.1 OBJECTIVE 1: Strengthening the GOC to enforce gold mining legislation

Objective 1 Problem Statement

The GOC entities in charge of regulating the gold mining sector face several challenges that limit their ability to enforce legislation: (i) inadequate regulatory framework; (ii) limited information on formalization options; (iii) budget, institutional capacity and staffing limitations; (iv) administrative decisions that unintentionally create disincentives or obstacles to legalization, and (v) illegal miners who demonstrate limited capacity and willingness to change. This lack of enforcement capability on the part of the GOC encourages continued illegality and increases the negative environmental impacts of illegal mining, particularly the use of mercury and the pollution of air, water and soil that have significant impacts on human health. Better governance involves both strengthened GOC capacity to regulate the sector as well as the active participation of mining titleholders and MPUs that are willing to support legalization/formalization, thus resulting in improved social and environmental performance.

Objective 1 Expected Results

Expected Result 1. Strengthened Capacity in GOC entities to enforce gold mining legislation.

Relevant GOC entities will be assisted at the national level, such as the MME, MADS, the National Environmental Licensing Agency (ANLA), ANM, and the Rural Development and Land Agencies, in consolidating and updating the regulatory framework to create an enabling environment for ASM formalization and legalization, when a clear expression of demand by the GOC exists to do so. This includes support for designing incentive mechanisms, such as innovative financial instruments to provide finance for small scale informal miners, and control mechanisms.

Oro Legal will work with regional and municipal governments as well as with regional environmental authorities to build more sustainable capacities for implementation and enforcement of mining regulations. This includes improving their knowledge and understanding of the relevant existing legislation and GOC programs on ASM formalization/legalization and mercury use reduction programs, as well as providing support to implement mechanisms for fast and effective processing of all requests for formalization. The Activity will also facilitate interaction among mining companies and mining titleholders as a mechanism for legalization/formalization.

Expected Result 2. Participation of ASM organizations, indigenous and Afro-Colombian communities in formalization programs strengthened.

Oro Legal will assist ASM associations, indigenous and Afro-Colombian communities in accessing GOC formalization programs. Viable routes for formalization will be identified, according to conditions on the ground. To the extent possible, Oro Legal will support their transition towards legalization and formalization. Promoting and strengthening miners' associations, building their administrative and technical capacities in ASM, and providing legal advice throughout the formalization process are key activities towards achieving results.

Expected Result 3. Technical assistance and training provided to ASM

Training and technical assistance will be provided to ASM operations to: (i) reduce and ultimately eliminate the use of mercury for gold extraction and (ii) minimize and mitigate the environmental impacts of ASM operations. Support in preparing and implementing PTOs and PMAs will be provided.

4.2 OBJECTIVE 2 Increasing the capacity of the GOC, communities and the private sector to address environmental impact caused by illegal gold mining.

Objective 2 Problem Statement

Lack of state presence and capacity to enforce legislation contributes to the expansion of areas degraded by illegal mining operations. Innovative approaches to rehabilitate degraded areas are needed. Participation of the GOC, private sector, CCs and mining associations, and land owners is required to address the problem. Previous experience in the Bajo Cauca region of Antioquia during the BioREDD+/Mining component shows that a joint venture approach to rehabilitation of degraded areas is feasible. Forestry plantations are also aligned with the Colombian Low Emissions Development Strategy (LEDS) and reforestation has been identified as a Nationally Appropriate Mitigation Action (NAMA) to mitigate climate change. In the same vein, income diversification options can take pressure off the mining sector and integrated water management approaches can improve the quality of drinking water to mining communities.

Objective 2 Expected Results

Expected Result 1. Reforestation in areas degraded by unauthorized ASM operations (Pasivos ambientales).

Oro Legal will facilitate the design and implementation of protocols and support mechanisms for the provision of technical, financial and legal assistance for land rehabilitation investments. In Antioquia, this includes the identification of viable degraded areas that are clustered to attain the minimum area needed to make the reforestation activity financially feasible. Oro Legal will build on the previous experiences of other USAID-funded forestry programs (BioREDD+, Colombia Forestal, MIDAS, etc.) while proposing business models where landowners, communities, private sector and GOC can participate. In Chocó, given significant differences in land tenancy and governance arrangements, rehabilitation will be based on signed, voluntary agreements with Afro Colombian CCs rather than private contracts.

Expected Result 2. Income Diversification Options for ASM communities promoted

A significant proportion of the population involved in ASM operations are not necessarily miners by training or tradition. Displaced and unemployed people are also involved in unauthorized mining because of a lack of alternative income generating activities. Oro Legal will work with mining associations, rural communities in gold mining areas and degraded areas, and land owners in the promotion and establishment of income diversification options using a value chain approach. In Antioquia, the focus will be on honey production, while in Chocó priority will be given to annatto production. Other options may also be considered.

Expected Result 3. Drinking water quality improved

Illegal mining deteriorates the quality, quantity and availability of water in several ways. Direct discharge of mercury and heavy metals into river streams, erosion of river beds and catchment deterioration by unregulated alluvial mining activities are part of the problem. Poor access to safe water threatens local populations and impacts human health in urban areas, whether they are involved in mining or not. Oro Legal will support integrated water catchment management to improve water supply systems for local urban areas and the design and implementation of sustainable financial mechanisms to pay for it.

Oro Legal is expected to undertake its activities in 22 municipalities in Antioquia and Chocó (see Table 4-1 below). These two departments account for almost 75 percent of the gold mined in Colombia. Oro Legal is cognizant that should a peace agreement be reached in the near future, or important changes in other aspects of the operating environment occur, USAID may request that the Activity re-orient efforts to prioritize new municipalities.

Table 4-I Oro Legal Prioritized Municipalities in Antioquia and Chocó

Department	Sub Region	Municipality
Antioquia	Northeast	Remedios
		Segovia
		San Roque
	Western	Buriticá
	Lower Cauca	Nechí
		Tarazá
		Caucasia
		El Bagre
		Cáceres
		Zaragoza
	Valle de Aburrá	Don Matías
		Barbosa
Chocó	Middle and Upper Atrato River	Río Quito
		Atrato - Yuto
		Quibdó
		Cantón de San Pablo
		Cértegui
	Lower, Middle and Upper San Juan River	Condoto
		Unión Panamericana
		Istmina
		Nóvita
		Tadó

5. SIGNIFICANT ISSUES

Informality in the possession, use, and exploitation of land subject to gold mining

The Oro Legal Activity is not meant to directly resolve the issue of formalization in the possession, use, and exploitation of land *per se*. However, in Colombia, rights to subsoil minerals are separate from land tenure and property rights, a fact that must be considered during implementation of actions to legalize and formalize MPUs and rehabilitate land degraded by gold mining.

Informality in extracting, processing, and marketing gold

Informal gold mining causes serious impacts on the environment. The primary impacts from informality along the gold production chain to be addressed by Oro Legal include: degradation and loss of soil; damage to water resources; deforestation; failure to implement and uphold industrial safety and occupational health standards and; poor organization of ASM operations.

Use of mercury in the gold mining process

Reducing the use of mercury by stakeholders receiving support from Oro Legal in Antioquia and Chocó is a priority. By legalizing and formalizing MPUs and enhancing awareness of improved technology used in gold extraction processes, the use of mercury is expected to decrease and gradually be eliminated, thus reducing impacts such as emissions and exposure from mercury vapors, contamination of soils and water resources, and health risks to workers, their families, and communities. Mercury will continue to be used by MPUs as the Activity works to identify and promote zero-mercury alternatives. In this interim period, the Activity will instruct MPUs on ways to handle hazardous waste, including mercury, and alternatives for its disposition in accord with Colombian law. However, Oro Legal will not directly support activities to collect, store, transport or dispose of this waste. In specific cases, the Activity may support drafting of hazardous waste management plans by MPUs.

Income diversification options for ASM that cannot be legalized and formalized

Oro Legal will support small gold miners who cannot become legal by developing rural economic alternatives. The risks of clearing new forests to establish crops is expected to be low as new cultivation or silvopastoral systems will be restricted to areas already used for agriculture. Low input cropping systems will be promoted and the use of any chemical inputs will follow the requirements of the USAID Pesticide Evaluation Report & Safe Use Action Plan (PERSUAP) approved for Colombia and/or be covered by a USAID waiver issued to Oro Legal.

Management of water catchments

Contamination of water supplies from upstream degradation and inadequate potable water systems pose serious public health risks. In Antioquia, mining is not the main source of water contamination, rather land conversion to agriculture and livestock grazing and poor agricultural practices pose the greatest threats to the quality and quantity of water. Poor water quality and depressed availability is largely caused by soil erosion, sedimentation of waterways and contamination by animal and human waste. In Chocó, municipal water

systems that source water from large rivers are at risk of contamination from many of the same causes as in Antioquia, as well as from sediments, organic matter, oil and fuel, heavy metals and other pollutants originating from alluvial gold mining activities upstream from water intakes for municipal water systems.

This being the case, Oro Legal will employ an integrated approach to improve water quality and secure sustainable water supplies in selected pilot catchments based on: (i) conservation of upper water catchment areas; (ii) improved water capture, storage, and treatment systems and (iii) novel financing mechanisms to better link demand to supply. Improvement in land-use practices is a long-term endeavor that requires well-targeted planning to build consensus among landowners and political commitment by local authorities, complemented by the right mix of incentives and disincentives to encourage change. Oro Legal will explore the feasibility of implementing small water funds in select municipalities as a mechanism to promote long term financial sustainability.

6. DESCRIPTION OF ALTERNATIVES

6.1 Alternative A

Alternative A consists in taking no actions to mitigate impacts. It is the “business as usual” or null hypothesis. Thus, it is reasonable to assume that Alternative A will, over time continue to reflect the baseline conditions of municipalities evaluated in Antioquia and Chocó (see Annex II).

6.2 Alternative B

Alternative B corresponds to activities currently proposed in Oro Legal. The activities to be performed are described below.

Informality in the possession, use, and exploitation of lands subject to gold mining

Actions intended to achieve the desired future conditions involve building greater capability over time for implementation and enforcement of mining regulations, and for implementing quick, effective processing for better control of small-scale informal mining. Oro Legal will assist small mining associations, Afro Colombian CCs and MPUs to take advantage of available routes to legalization and formalization. Activities include:

- Building sustainable capacity for implementation and enforcement of mining regulations. This includes enhancing knowledge and understanding of existing legislation and GOC programs on ASM formalization/legalization and mercury use reduction programs, as well as improving mechanisms for fast and effective processing of requests for legalization/formalization.
- Assistance to relevant GOC entities at the national level in consolidating and updating the regulatory framework to create an enabling environment more conducive to ASM formalization and legalization; this includes support for designing incentive mechanisms, innovative financial instruments to provide finance for small scale informal miners, and control mechanisms.
- At the regional level, Oro legal will expand knowledge of legalization and formalization, improve the quality of processes and speed of service delivery in Antioquia, develop nascent technical capacity in Chocó, and support CARs so they increase their presence in the sector.
- At the municipal level, Oro Legal will foster greater awareness on the part of municipal authorities regarding obligations and opportunities to intervene in local mining issues (mine closure, land use planning for mining activities, etc.).

Informality in extracting, processing, and marketing gold

Oro legal will work with MPUs, miners’ associations, and Afro Colombian CCs to build their administrative and technical capacities in ASM, providing legal advice and TA throughout the legalization/formalization process and where necessary, co-financing important operations and work plans and environmental instruments. Activities include:

- Training and TA provided to MPUs, including support in preparing and implementing environmental impact assessments or environmental management plans.
- The development and application of a rigorous and measurable formalization standard to be applied to all legalized MPUs undergoing formalization.
- Facilitation of agreements between mining title holders and MPUs to legalize small miners via operations contracts or formalization subcontracts.

Use of mercury in the gold mining process

Improving gold recovery is key to reducing mercury consumption and waste. Oro Legal will demonstrate to miners that moving away from mercury will not reduce their profit margins. This will build trust with miners, enable access to monitoring information, and underpin mercury reduction. Interventions will be differentiated by type of mining operation. Activities include:

- Baselines and methodologies established to comprehensively, yet cost effectively, measure mercury used in gold processing and air contamination levels.
- Training and TA used to better disseminate the advantages of improved technology.
- Joint work undertaken with environmental authorities to promote installation of mercury control equipment such as condensers and retorts in gold shops to reduce emissions of mercury vapor and develop protocols for safe handling and disposal of recovered mercury.

ASM alluvial operations

Technically and financially viable low or zero-mercury gold processing alternatives for small-scale alluvial operators will be promoted. The groundwork laid by BioREDD+/Mining (and subject to the continued existence of viable legalization routes) makes it feasible for some MPUs to consider entering new markets for responsibly produced gold.

ASM hard-rock operations

Oro Legal will assist legalization/formalization of hard-rock miners operating within the titles of private mining companies by which MPUs sell their ore under negotiated purchase contracts. The ore is processed at large, centralized no-mercury processing plants, resulting in higher recovery rates and less risk to human health and the environment. Formalization subcontracts can also give small-scale miners access to zero-mercury technology.

Small dredging operations

Most small dredging operations are two or three-person teams who operate small dredgers on the banks of rivers and large streams. Individually, these operations yield small amounts of gold, yet they contribute disproportionately to mercury contamination due to the sheer volume of operations, the large amount of mercury used and its gross mishandling. Assisting these artisanal miners is somewhat controversial, but they present opportunities to make significant progress toward eliminating mercury. Continuing the work begun under BioREDD+/Mining, Oro Legal will work with three mining associations to support the processing of ore at central processing plants where simple zero-mercury (gravimetric) technology is employed.

Gold shops

Most MPUs bring gold amalgam or concentrated ore to gold shops, where large amounts of mercury are vaporized and emitted into the atmosphere in densely populated urban centers. As Oro Legal works to reduce MPUs' mercury use, the Activity will collaborate with CARs and gold shops to install simple, locally manufactured equipment to capture mercury vapor and develop protocols for safe handling and disposal of recovered mercury. Actions at this key link in the gold supply chain are among the most cost-effective way to prevent emissions of highly toxic airborne mercury.

Gold panners

Despite their numbers - up to 12,000 in Antioquia and up to 20,000 in Chocó - gold panners are among the most disenfranchised groups in the sector, and upwards of 30 percent are women. An average daily production of only 0.75 grams, multiplied by many thousands of gold panners, equates to around 4.5 tons of gold per year (9 percent of national production). However, unless they are officially registered in a municipal registry of gold panners “censo de barequeros”, these operators cannot legally sell their gold. Oro Legal will work with municipalities to set up registries to formalize gold panners.

Photo 6-1 - Photo 6-2 Alluvial Gold Mining in Bajo Cauca



Photo 6-3 Small Dredges in Bajo Cauca



Photo 6-4 Alluvial Gold Mining in the Department of Chocó



Mercury monitoring

Oro legal will develop and execute a Monitoring and Evaluation (M&E) Plan to identify indicators and targets for evaluating performance over the life of the Activity to determine whether progress is being made toward objectives and results. Monitoring of mercury is a key part of the plan and will involve three levels of monitoring. These are:

1. At the level of the mine, based on a representative sample of MPUs covering the different types of mining operations supported by Oro Legal (underground hard rock, alluvial and small, river dredging). A sample of MPUs entering Oro Legal will be

monitored using a standard mercury mass balance methodology to determine mercury consumption by MPUs. This will allow Oro Legal to establish the reduction in mercury released to the environment over time.

2. At the level of local gold shops, where gold is traditionally traded and where mercury, used as an amalgam in the gold extraction process, is burned off to calculate the purity of the gold and the final weight to establish the price paid to miners. This process generates airborne mercury emissions. A baseline for each gold shop will determine current airborne mercury emissions given the mathematical relationship between mercury in its liquid and gaseous forms. Monitoring of reductions in mercury contamination over time will be undertaken as the gold shops incorporate better industrial practices and improved equipment.
3. As part of broader mercury monitoring activities and communications campaigns, an airborne mercury baseline will be established in 9 municipalities. An initial baseline estimate will be calculated via the implementation of an airborne mercury sampling protocol reviewed by the MADS. Field measurements will be performed to map emission levels from gold shops in locations where many vulnerable segments of the population are exposed. The baseline will determine average gaseous mercury concentration levels (ng/m^3). Subsequent monitoring will be performed annually to allow Oro Legal to present robust scientific findings in communications campaigns that can be easily assimilated by decision-makers and the public at large, to stimulate public policy initiatives and other actions to control mercury emissions⁶.

Rehabilitation of degraded areas with Acacia mangium plantations in Antioquia

Experience during BioREDD+/Mining and elsewhere has shown that reforestation of areas degraded by mining with *Acacia mangium* is both technically and financially feasible. Oro Legal will use broadly the same model to rehabilitate land in Antioquia. This consists of several steps:

1. Site selection based on the level of degradation and risk to adjacent natural resources, confirmed land title, potential to group plantations into contiguous areas of land to gain economies of scale to increase impact, and signing of long-term reforestation contracts between landowners and private reforestation companies.
2. Site layout and preparation: mapping, recontouring using heavy equipment to approximate the original topography (landscaping) and to fill-in areas that were flooded during exploitation, as well as digging holes for planting.
3. Production of quality tree seedlings from commercial growers and transportation to planting sites.
4. Plantation establishment at a density of 1,100 tree seedlings/ha (3m x 3m).
5. Preparation and implementation of a long-term plantation management plan.

⁶ Given attribution issues, this latter monitoring activity will not formally contribute to Oro Legal's indicator set within the M&E Plan.

Oro Legal support to reforestation in Antioquia will be done through subcontracts with qualified, experienced commercial reforestation companies and other organizations under a 1:3 cost sharing arrangement between the Activity and the subcontractor and/or landowner⁷.

Photo 6-5 and Photo 6-6 Plantation of *Acacia mangium* in Bajo Cauca



Natural/assisted regeneration of degraded mining areas in Chocó

Mining degradation in Chocó typically occurs around fragile river systems or in higher elevations. In both cases, natural tropical forest is destroyed. For this reason, natural regeneration is proposed. The objective of natural regeneration is to quickly and inexpensively revegetate the degraded sites with pioneer species found in nearby forests and, over time, approximate the composition and structure of these secondary forests (there are no primary forests located near large to medium-sized rivers in the proposed Oro Legal intervention areas). A key factor in the success of natural regeneration is the distance of degraded areas to natural forest edges; the closer the natural forest, the higher the likelihood of a broader array of pioneer and other species successfully propagating. It is expected that forest species that are scarce in the primary forests (high value species with heavier seeds) will not be present in areas regenerated naturally.

Based on field observations and discussions with IIAP, it is expected that after one year, naturally regenerated degraded lands will be dominated by seedlings that are dispersed by wind and, in some cases, bats and birds. These could include yarumo (*Cecropia peltata*), siete cueros (*Tibouchina lepidota*, in general plants of *Melastomataceae* family), balso (*Ochroma pyramidale*), and escobo (*Alchornea triplinervia*). As would be expected, seed deposition in the

⁷ To better understand the change in biodiversity resulting from rehabilitation activities in degraded areas, Oro Legal will design a simple, low cost monitoring protocol to be implemented within *Acacia* plantations and adjacent areas. Biodiversity indicators that will be monitored could include soil micro fauna and flora, herbaceous and woody plants and presence of bird species. Soil quality indicators could also be monitored, including the reconstitution of the O and A horizons, organic matter, macro-nutrient availability and biomass of soil microorganisms.

short-term will generally be lower in the interior of degraded areas, both in species richness and numbers of seeds, than in areas closer to seed sources in nearby forests. Over time, the pioneer species will establish micro-climates and roosting places for birds, bats, and mammals, thus allowing for the natural establishment of a richer variety of tree species. Over the medium term, this will result in the establishment of nearby, intact secondary forests. Key to effective natural regeneration are measures such as soil leveling which maintain low slopes that prevent erosion, and protection and monitoring of these areas to prevent new encroachment. Natural regeneration should be underpinned by long term agreements with Afro Colombian CCs to ensure that the land is not affected by future mining activity.

Implementation of natural regeneration would typically involve:

1. Selection of areas to regenerate per the intensity and length of time during which the area was affected by gold mining.
2. Signing of agreements, specifying the period in which natural regeneration will occur and the responsibilities and activities to be carried out by all parties.
3. Analysis of a reference ecosystem found on adjacent land to study which species could colonize the area, and to determine the presence of invasive species.
4. Recording of topography, presence of mercury or heavy metals, water availability and rainfall regime.
5. Preparation of site, including ground levelling.
6. Monitoring of the area every 6 months for at least 3 years, to confirm growth rates, survival rates and tree cover, patterns of natural succession and changes in soil characteristics⁸.

Under certain circumstances, natural regeneration will be assisted by enrichment planting of native species at low densities, where stocking of trees valuable to wildlife and for commercial purposes is suboptimum, and simple management practices which can easily be carried out by local communities like manual weeding, thinning, and pruning of valuable species once species become well-established on the site.

⁸ As noted in footnote 8, rehabilitation and changes in site specific biodiversity will be monitored and verified. Protocols will be developed that would ideally involve the participation of local landowners and communities. This could include socio-economic factors such as the commitment of the local community to the protection of restored areas, monitoring biophysical changes over time, and the number of people trained through the rehabilitation process. More information on monitoring of restored areas can be found in the manual “*Monitoreo a Procesos de Restauración Ecológica Aplicado a “Ecosistemas Terrestres”*” edited by the Instituto de Investigacion de Recursos Biologicos Alexander von Humboldt, 2015.

Photo 6-7 Naturally Regenerated Secondary Forest



Reducing the risk of mercury contamination in rehabilitated areas

In land subject to gold mining in Antioquia and Chocó, contamination by mercury, is a risk. If land rehabilitation involves a subsequent productive use (timber harvesting, production of pulp, agriculture, honey production using sap from reforested areas, etc.) effort should be made to ensure that mercury contamination is not present in these new products, including the following:

- Studies should be conducted in the areas to determine if mercury can migrate from the soil or water to trees and plants.
- In the event of mercury contamination being confirmed in trees, use of timber must be restricted to that which ensures that mercury will not be released into the environment.
- In the event of mercury being found in agricultural crops, production should be stopped and relocated to uncontaminated land.
- In the event of mercury being found in associated products (e.g. honey), the activity should be relocated to uncontaminated land.

Finally, it should be confirmed ex-ante that the presence of mercury will not inhibit the development of trees or plants.

Income diversification for ASM that cannot be legalized/formalized.

It is probable that for the bulk of small miners working informally/illegally in Antioquia and Chocó, legalization and formalization of their MPUs is unviable for technical, economic or policy reasons. This being the case, and recognizing this option is explicitly included in Colombian mining formalization policy, Oro Legal will develop income diversification activities. Building on previous experience of value chain development in USAID-financed projects in Colombia, these are largely conceived to be based on agroforestry productive systems such as annatto cultivation in Chocó. Some limited work with agro-silvopastoral

systems (cover crops, live fencing, land rotation, etc.) is also contemplated in Antioquia given the prevalence of cattle ranching.

Honey production in Antioquia

Exploiting the known symbiosis between *Acacia mangium* and beekeeping (specifically the production of sap at the joints between the main stem and the branches) Oro Legal will develop honey production in areas subject to land rehabilitation with acacia. Honey production “cells” will be developed with mining communities living close to plantations, based on a group of 45 hives, generating around twice the current Colombian minimum wage for families involved. Honey production has the advantage of significant participation by local women.

*Annatto (*Bixa orellana*) production in Chocó*

Annatto production has been undertaken in Chocó for many years and is a crop that is known to CCs. The upside is that there is a large shortfall in supply to international markets given that demand has grown significantly for the natural colorant (bixin) derived from the annatto seed which is used in cosmetics and food industries. The downside is that post-harvest handling, processing and transport are tricky, particularly in the high-humidity conditions of Chocó. To enhance possibilities of success, Oro Legal is proposing to produce annatto plants in local nurseries using verified genetic lines. To prevent exposure to mercury present in irrigation water, out-planting of seedlings would be undertaken in areas that have not been used for mining activities and which are located upstream of water bodies where there is evidence of illegal gold mining activities. Crop establishment (land preparation, weeding, planting, etc.) would generate local income early in the process. First harvests from newly planted annatto can be expected during the third year. TA would be provided to resolve the challenges associated with processing and transport and Oro Legal would also facilitate commercial contacts with buyers.

Photo 6-8 Annatto Plantation in the Municipality of Canton de San Pablo



Water catchment management

The provision of adequate quantities and quality of water to communities living in mining areas is an important objective of Oro Legal. The Activity will apply an integrated water resources management (IWRM) approach, including: (i) the conservation of upper water catchment areas; (ii) improved water capture, storage, and treatment systems⁹ and (iii) novel financing mechanisms to better link demand to supply. Improvement in land-use practices is a long-term endeavor that requires well-targeted planning to build consensus among landowners and political commitment by local authorities, complemented by the right mix of incentives and disincentives to encourage changes. Oro Legal will explore the feasibility of implementing small water funds as a mechanism to promote long term financial sustainability.

Photo 6-9 Water Catchment in the Municipality of El Bagre



Photo 6-10 Water Catchment in the Municipality of Condoto



⁹ Nevertheless, the Oro Legal will not fund any direct investment in water systems.

Creation of ASM Service Centers

The creation and operation of ASM Service Centers in the municipalities of Caucasia and Quibdó will provide ongoing TA, access to information, and support to legalization/formalization processes. The ASM Service Centers will play a major role in “reducing the distance” between local miners and national and regional agencies, facilitate the preparation and delivery of documents, and permit follow up on progress of reviews and approvals and maintaining MPUs and mining associations informed.

6.3 Alternative C

Alternative C goes beyond the previous alternative (B) and adds activities that are theoretically possible to undertake. They are largely the outcome of interviews undertaken with stakeholders in Antioquia and Chocó, supplemented by recommendations from the consulting team that undertook the EA.

Development of fish farming

To expand the portfolio of income diversification activities in Oro Legal, fish farming projects could be developed to meet local/regional demand, utilizing existing or creating new small ponds. The Servicio Nacional de Aprendizaje (SENA) has experience in this area. Prior to initiating any such activity, analyses should be undertaken on existing ponds (or of soil in areas where new ponds are planned) to rule out the presence of mercury or methylmercury in water and sediment. Once the presence of mercury has been ruled out, water-retaining clay soils should be selected, ensuring that water used in the ponds comes from rivers that are neither affected by illegal gold mining, nor exhibit evidence of heavy metals that can be transported and/or deposited in the ponds, or bio-accumulate in fish. If ponds are to be constructed in areas of possible contamination with mercury, the employment of a waterproof geomembrane to line the pond is recommended.

Further strengthening value chains in Chocó

During field visits in Chocó, it was observed that in the municipality of Cantón de San Pablo, the CORPOMISAN Corporation has plans to set-up a semi-industrial operation for drying and marketing annatto seed. It already has a warehouse and some basic machinery available, although the machinery assembly and testing have not yet been performed. In the same vein, another plant is being built at the Antonio Nariño University in Quibdó to extract bixin with a capacity to process 1 ton of seed/day. The laboratory is well equipped, but the plant has yet to be built and testing undertaken. These initiatives could be incorporated into Oro Legal. Similarly, existing warehousing and processing facilities could be utilized for other tropical products such as cacao, chontaduro, or palm hearts, to add value, improve transport and obtain a better price in the market. Producers, associated with private companies could undertake additional processes such as peeling, washing, cooking and cutting (for palm hearts, for example), drying and fermentation (for cacao, for example), quality control, packing or packaging. TA for development, production, logistics and marketing of the product could be managed by Oro Legal, together with producer associations.

Intensified cattle farming in Antioquia

As part of the micro-watershed management activities in Antioquia, intensified cattle systems could be promoted so that cattle production per hectare increases and pressure on natural ecosystems in the area decreases, providing an alternative income source for inhabitants of cattle farming regions. This would involve:

- Increased forage capacity per hectare.
- Increased milk production per animal.
- Enhanced management of grasslands (using grains and leguminous plants).
- Genetic enhancement by crossing local cattle with high-yielding breeds.

Regeneration of soils degraded by mining with vetiver grass in Chocó

In soils that are significantly degraded by illegal mining activities (principally in Chocó), vetiver grass could be planted. Vetiver is known globally for its use in erosion control and slope stabilization. At least one CC in Chocó has experience with using vetiver on soils affected by gold mining (See photos 6-11 and 6-12). TA could be provided to ensure planting is undertaken using cuttings from sterile seeds so it is non-invasive. Biomass could be used as a possible energy source. The only immediate downside is the high cost/hectare of vetiver establishment.

Photo 6-11 and Photo 6-12 Planting of Vetiver in the Department of Chocó



Payment for ecosystem services in Antioquia and Chocó

Over and above the design of new financial mechanisms to improve water quality and delivery, Oro Legal could consider the development of a payment scheme to reward land owners for the value of the ecosystem services arising from their land management. The

scheme could include payments for forest conservation, reforestation, natural/assisted regeneration and agroforestry or silvopastoral systems. Likewise, contributions to water conservation and adaptation to climate change could be included. For such a scheme to be successful, the ecosystem services must be clearly identified, including economic valuation of the ecosystem service, and indicators established to measure performance on the supply side. On the demand side, users of these services must be identified, a willingness to pay assessment/survey should be conducted, and a payment scheme established to reflect benefits that would not accrue to users in the absence of the scheme. Resources could be obtained via payments from direct beneficiaries and indirect users of services, international cooperation agencies and central government bodies, among others. In the case of water in particular, public utility companies could include charges as part of user invoicing.

Decontamination of ponds in abandoned mine sites

In abandoned mines on level terrain, which have ponds that show the presence of mercury in sediments, remediation treatments could be developed to extract mercury to levels that do not represent a risk to human health, thus permitting the development of fish farming, for example. Annex 4 includes a summary of the *in situ* and *ex situ* decontamination/remediation treatments that have been developed/tested mainly in the United States (US). The approximate costs of treatment are also listed in Annex 4, which can vary (by kg or m² of treated soil) depending on factors such as the concentration of heavy metals, soil characteristics, machinery and equipment required, on-site operating costs and cost of transportation of material to the treatment site. In general, these treatments are not cheap. And in the Colombian context there are two additional constraints: (i) the general absence of treatment facilities, and (ii) the limited effectiveness of these technologies in soils with high moisture and organic content; typical of Chocó.

Communications campaigns to protect water sources

During field visits in Chocó it was evident that communities deposit waste close to water sources, which is one of the main causes of loss of pumping efficiency within several water supply systems. Additionally, the presence of solid waste and sediments coming from upper micro-watersheds increases the cost of water treatment and maintenance of drinking water treatment plants; it is even necessary to clean the water intakes manually with some regularity to prevent pressure drop in the water supply system. Given this, communications campaigns could be initiated, aimed at preventing the inappropriate disposal of solid waste and promoting the conservation of micro-watersheds supplying water to local aqueducts. The campaigns could be undertaken in association with local public utility companies, mayors' offices, Codechocó and Corantioquia, among others.

Photo 6-13 Water Intake of Quibdó's Potable Water Supply System



Photo 6-14 Solid Waste Close to the Water Intake of Quibdó's Water Supply System



7. ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Geographic analysis

The following maps¹⁰ illustrate the legal status of lands in the different regions and sub-regions where Oro Legal will initially operate. The geographic analysis focuses on the presence of officially recognized protected areas and ethnic territories (indigenous or Afro-Colombian) that have implications for Oro Legal implementation. Designated protected areas prohibit certain anthropogenic activities. These areas include National Natural Parks, Forest Reserves declared by Law 2/1959, uplands, and other regional and local protected areas. Areas with ethnic communities correspond to the collective territories granted by the GOC under Law 70 to indigenous, tribal and Afro-Colombian communities for the use, management and conservation of these areas.

Both sets of land classifications place requirements on Oro Legal. In the case of protected areas, no mining or agroforestry activities can be carried out therein; however, per resolution 1274/2014, ecological restoration, recuperation or rehabilitation activities that are part of sanctioned projects or programs may be carried out in protected areas¹¹. In the case of Forest Reserves, the procedures established by the MADS must be applied to first declassify areas that will be subject to mining or agricultural production. The Oro Legal Activity will not advocate for or support changes in protected area status and will limit activities to the target municipalities outside of protected areas.

Likewise, if Oro Legal undertakes activities within indigenous or Afro-Colombian territories, it will do so based on signed agreements with the elected governing boards of CCs, based on formal CC consent and applying any relevant GOC regulations where necessary. If beneficiaries are members of an indigenous or Afro-Colombian community and mining is taking place within its collective lands, these groups will be required to apply for the corresponding mining titles and permits based on procedures established by law.

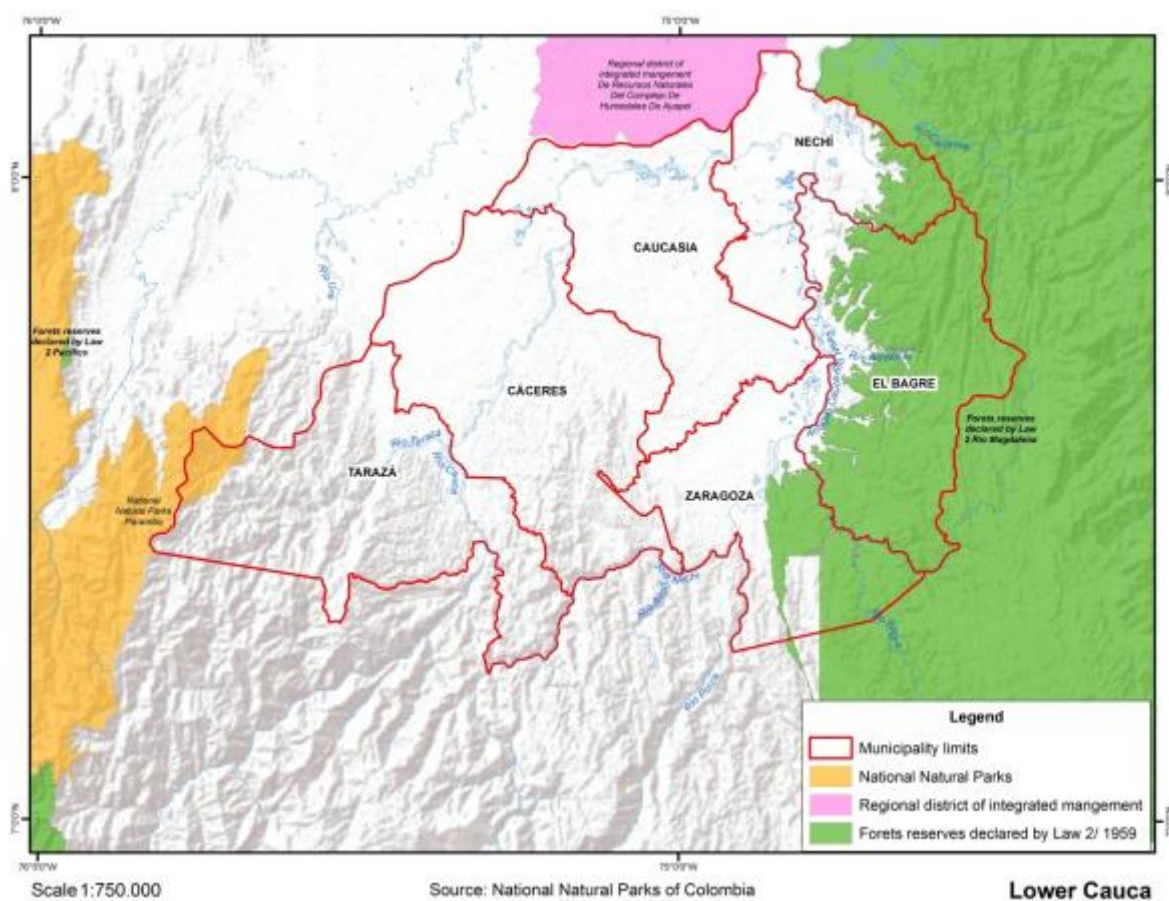
Accordingly, the maps below delineate the geographic field of action of Oro Legal, depicting the location of protected areas and ethnic territories in initial target municipalities.

¹⁰ Maps of protected areas and ethnic communities in Antioquia and Chocó can be found in high resolution in Annex 5.

¹¹ Per resolution 1274/2014, those activities must be included in projects initiated by environmental authorities, by the National Natural Park authority, local authorities, or in proposals presented by private individuals, authorized by environmental authorities.

Near the eastern side of the Bajo Cauca sub-region in the municipalities of El Bagre, Zaragoza and Nechí, there are areas that were declared Magdalena River Forest Reserves by Law 2/1959. Thus, Oro Legal must assess the exact location of planned interventions in these municipalities to avoid incursions into this Forest Reserve. Also, the regional integrated management district of Ayapel, which encompasses a wetland complex, is located near Caucasia and Nechí, and a small fraction of the Paramillo National Park is located in the municipality of Tarazá. (Map 7.1).

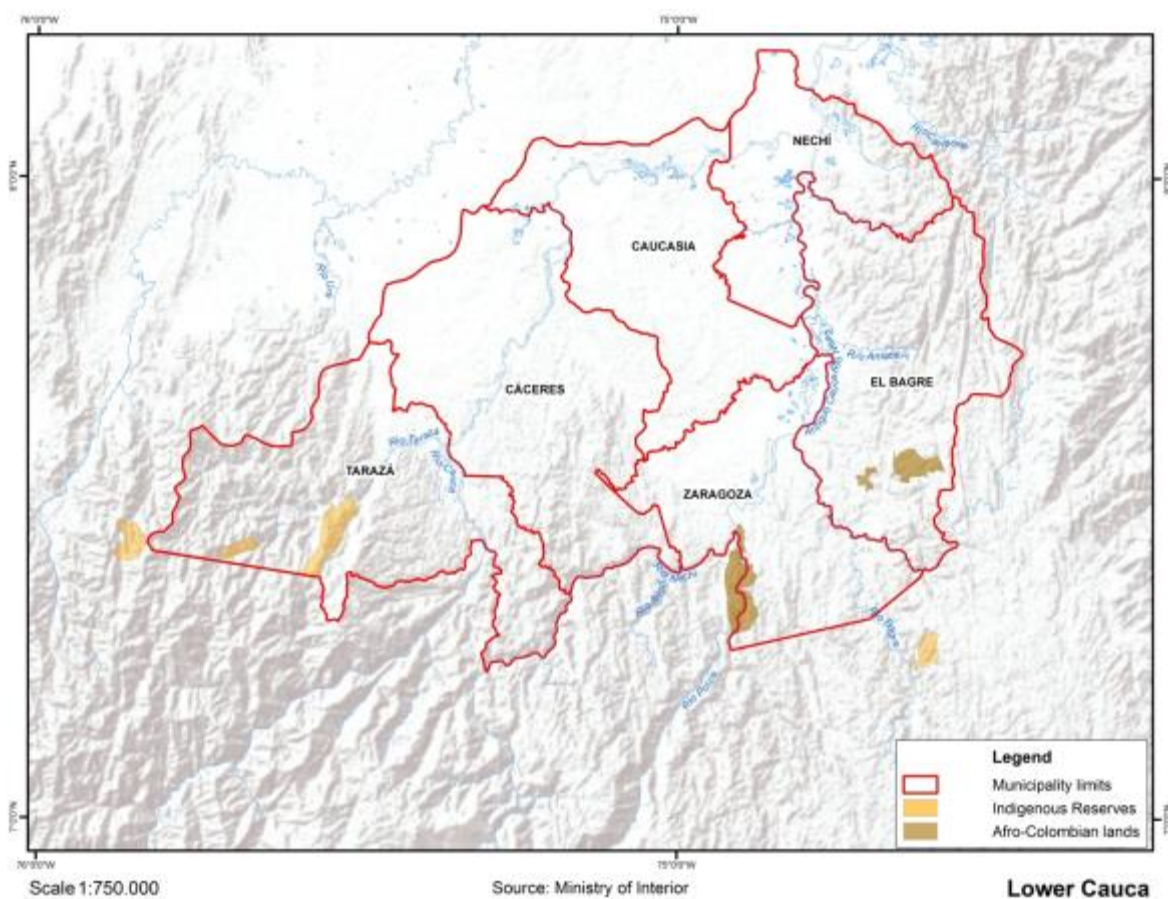
Map 7.1 Bajo Cauca Sub-region – Protected Areas¹²



The Bajo Cauca sub-region contains indigenous and Afro-Colombian CC territories. The indigenous territories are located in the central-southern area of the municipality of Tarazá and El Bagre. The Afro-Colombian communities are located in the municipalities of El Bagre and Zaragoza. (Map 7.2).

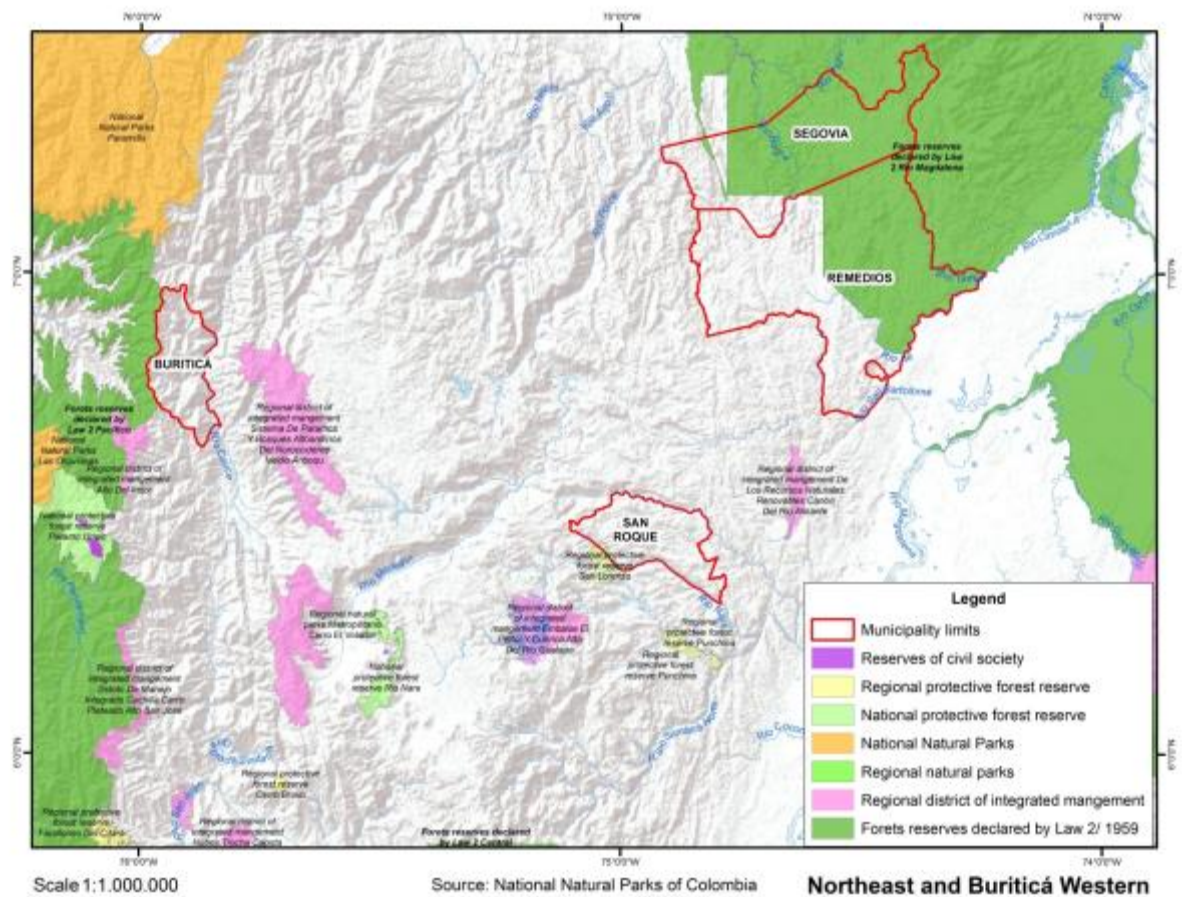
¹² The protected areas in Colombia are classified according to Decree 2372/2010.

Map 7.2 Bajo Cauca Sub-region – Ethnic Communities



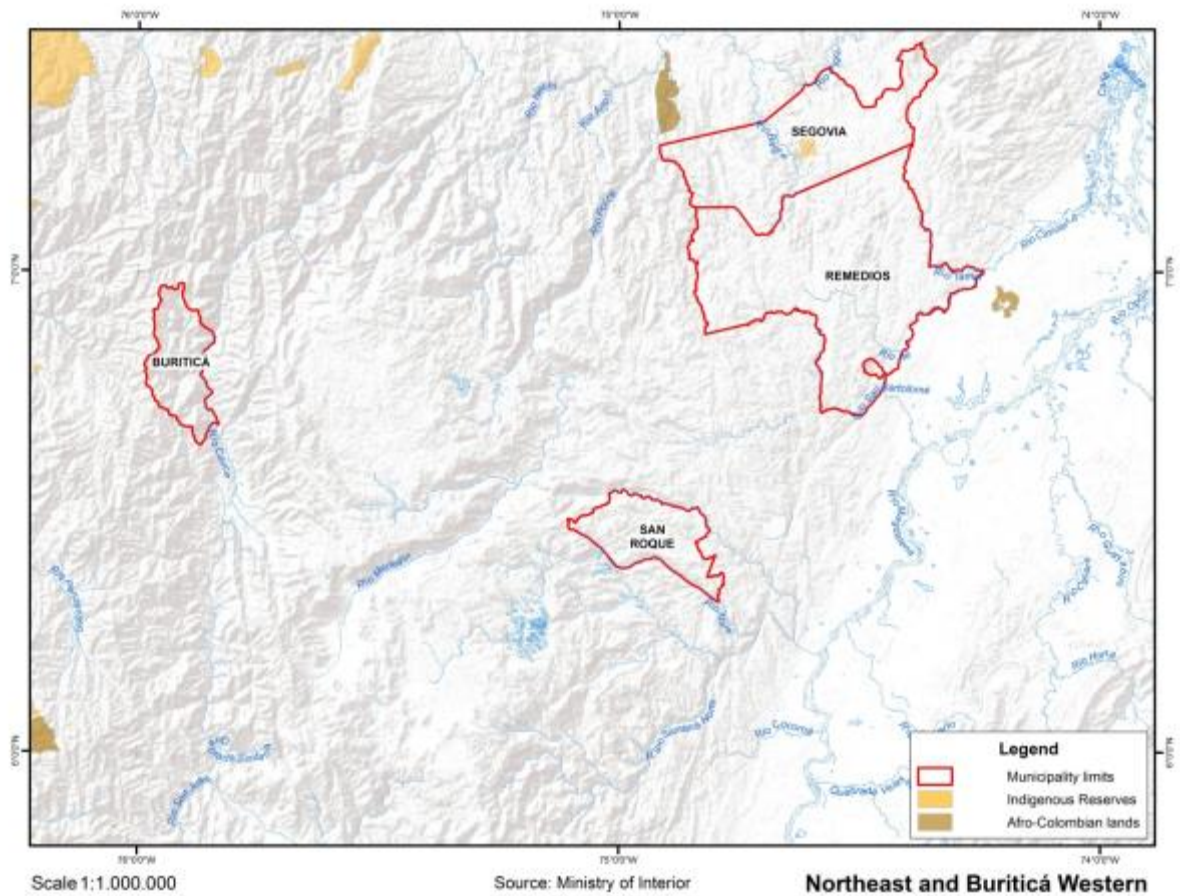
In the Nordeste Antioqueño sub-region, large portions of the municipalities of Remedios and Segovia have been declared part of the Magdalena River Forest Reserve. In addition, the municipality of San Roque includes a small area of the San Lorenzo Regional Protected Forest Reserve. The municipality of Buriticá does not contain protected areas, but it is bordered by the Pacific Forest Reserve. (Map 7.3)

Map 7.3 Nordeste Antioqueño Sub-region and the Municipality of Buriticá – Protected Areas



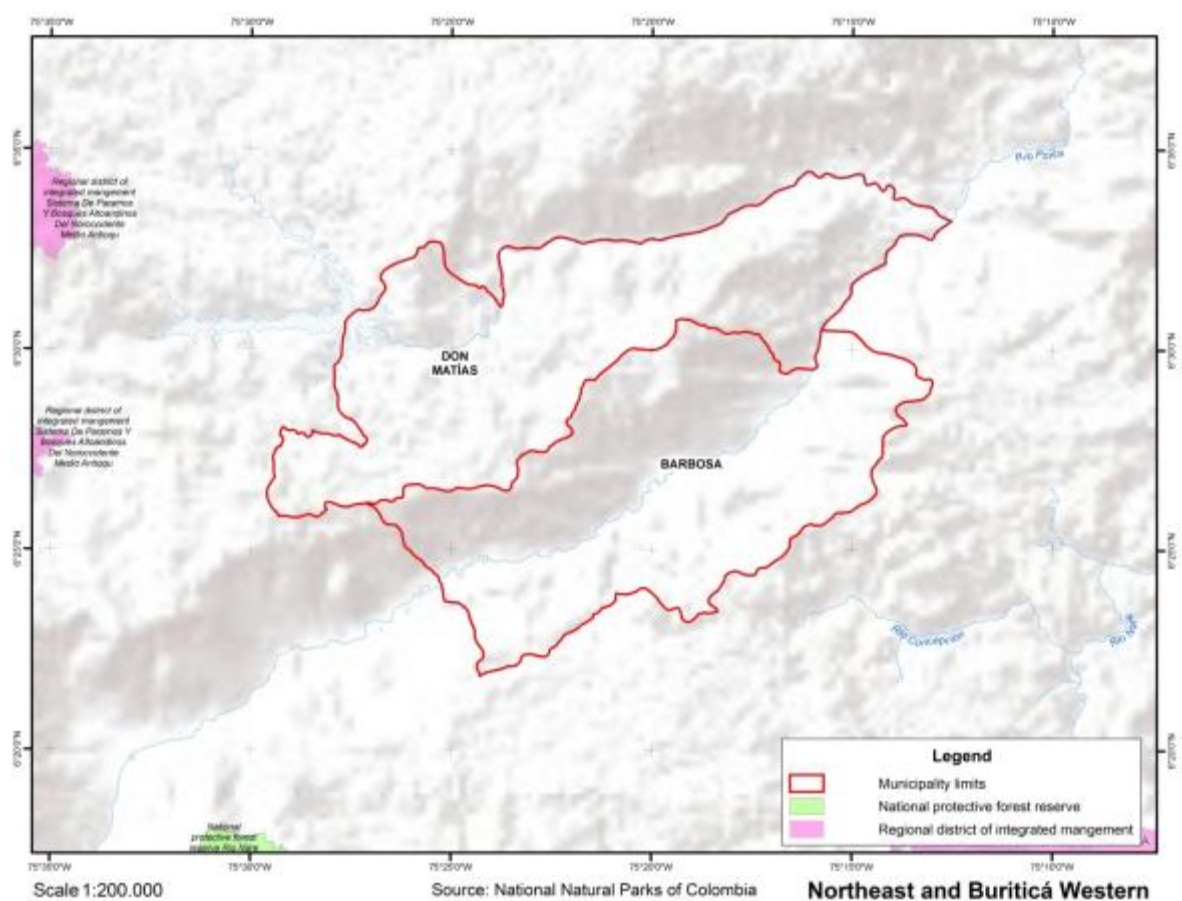
In the Nordeste Antioqueño sub-region and the municipality of Buriticá, there is only one indigenous reserve located in the municipality of Segovia. (Map 7.4)

Map 7.4 Nordeste Antioqueño and the Municipality of Buriticá – Ethnic Communities



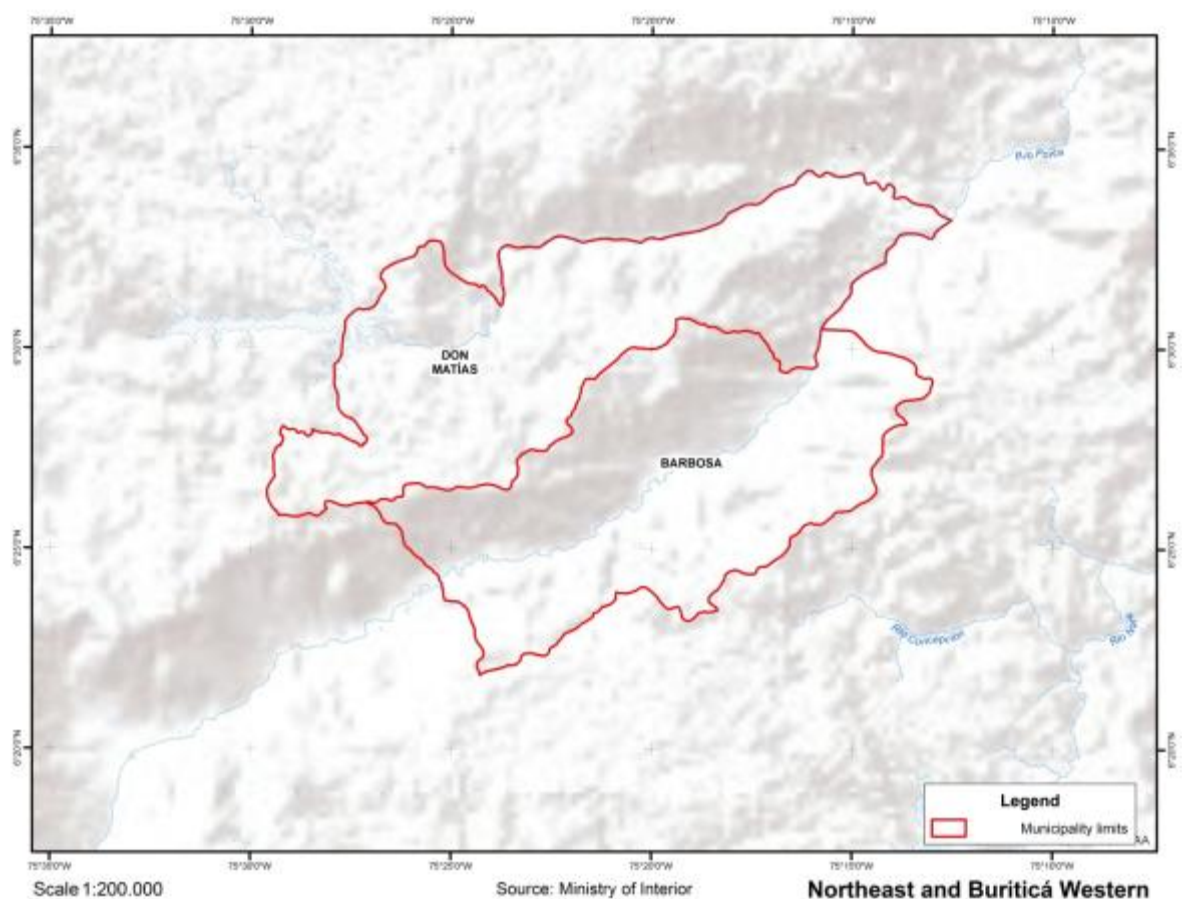
In the Valle de Aburrá and in the municipality of Don Matías, there are neither protected areas nor Forest Reserves. (Map 7.5)

Map 7.5 Valle de Aburrá and the municipality of Don Matías – Protected Areas



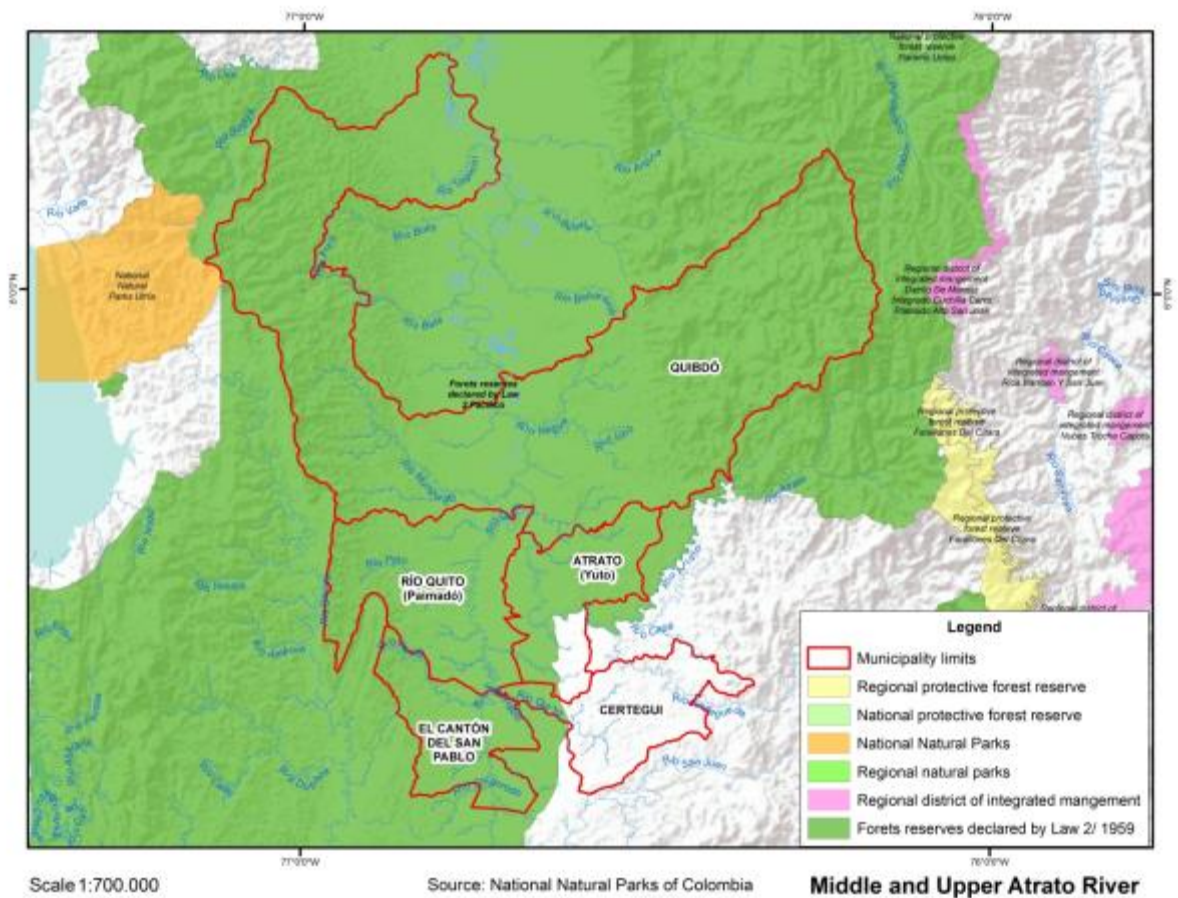
In the Valle de Aburrá area and the municipality of Don Matías, there are neither indigenous reserves nor Afro-Colombian territories. (Map 7.6)

Map 7.6 Valle de Aburrá and the Municipality of Don Matías – Ethnic Communities



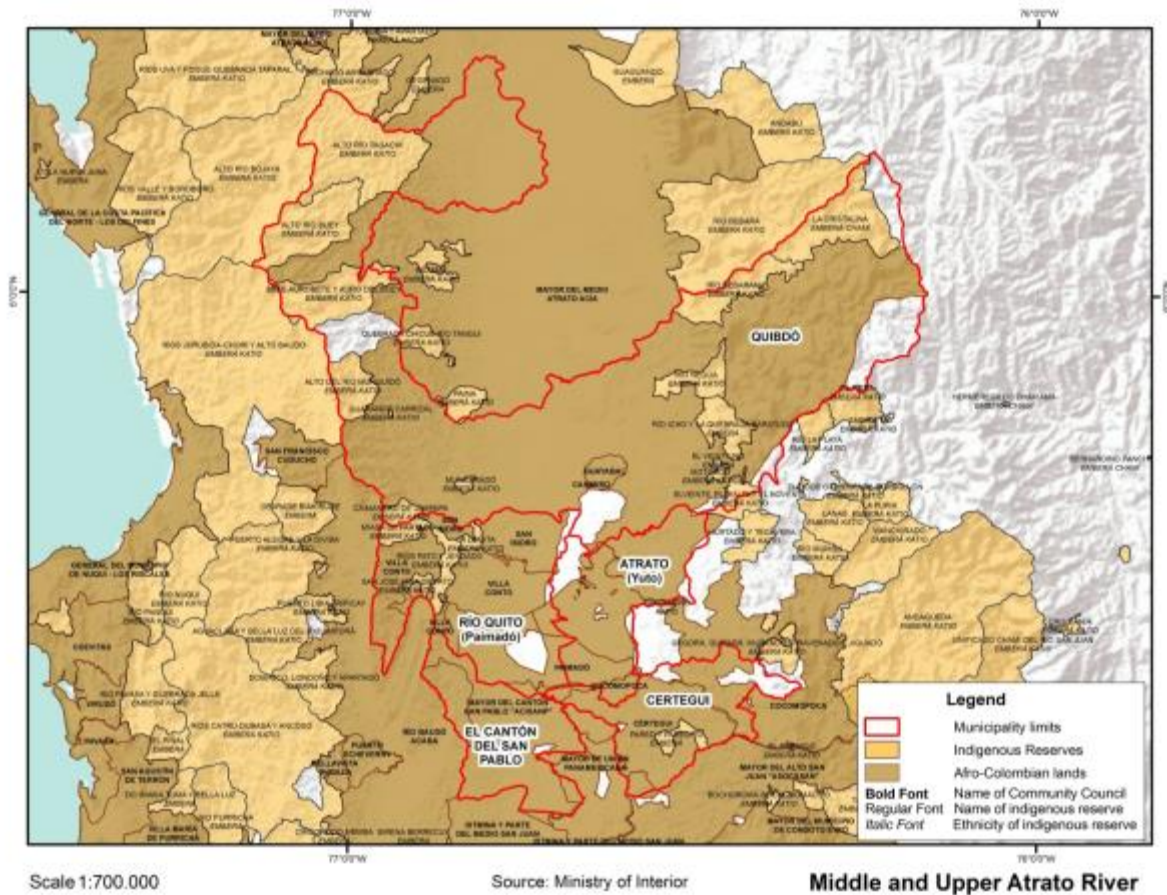
Much of the Pacific region of Colombia was declared a Forest Reserve by the Law 2/1959, creating the Pacific Forest Reserve. As a result, almost the entire Middle and Upper Atrato sub-region overlaps with the Pacific Forest Reserve. As illustrated in Map 7.7, the municipalities of Quibdó, El Cantón de San Pablo, Río Quito and a significant area of the municipality of Atrato – Yuto are located entirely in the Forest Reserve protected by Law 2, as well as a small percentage of the municipality of Cértegui.

Map 7.7 Middle and Upper Atrato River Sub-region – Protected Areas



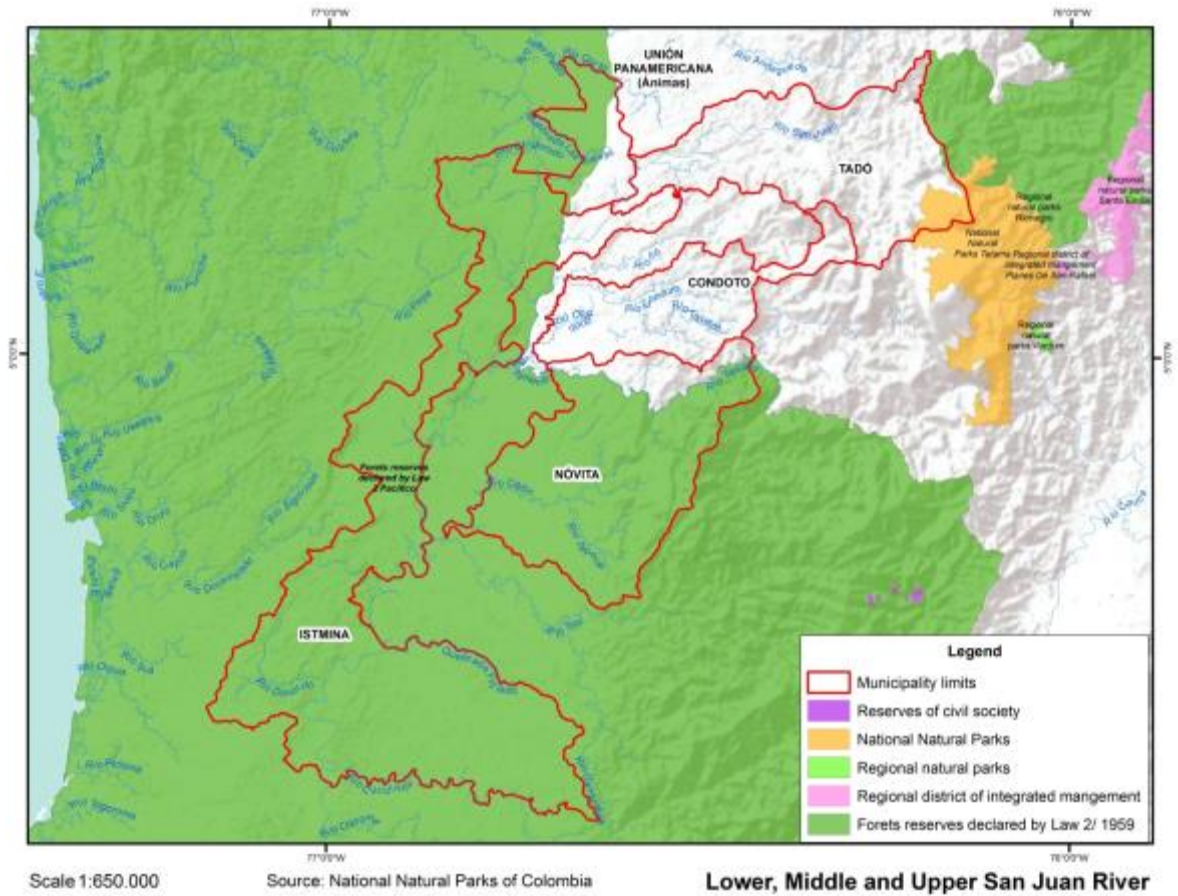
As shown in Map 7.8, in the Middle and Upper Atrato River sub-region, the municipalities of Quibdó Atrato – Yuto, El Canton de San Pablo, Cértegui and Río Quito overlap almost entirely with indigenous and Afro-Colombian territories.

Map 7.8 Middle and Upper Atrato River Sub-region – Ethnic Communities



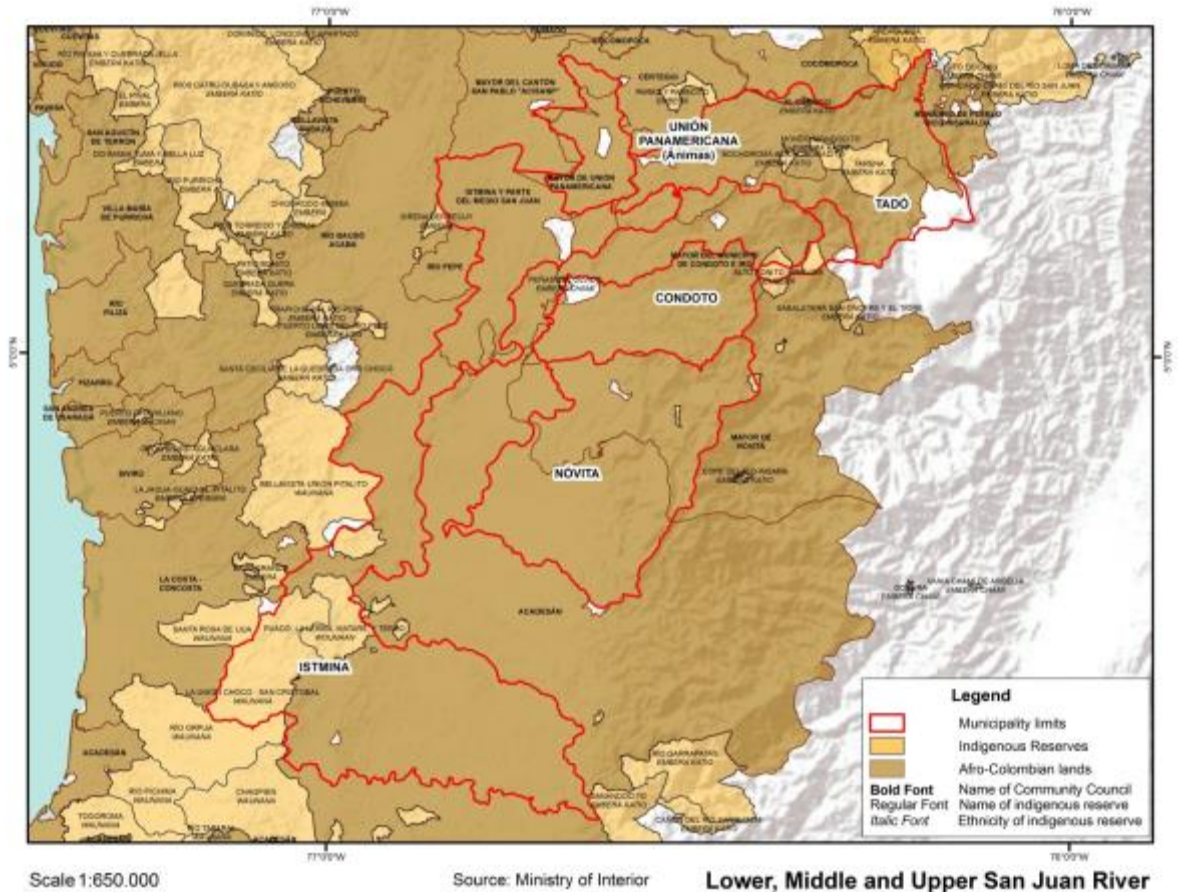
Four of the municipalities in the Lower, Middle and Upper San Juan River basin where Oro Legal will operate fall entirely or partially within the Pacific Forest Reserve created under Law 2/1959. (Map 7.9). The municipalities of Condoto and Tadó are located outside the Forest Reserve. However, the Tatamá National Park is also in this sub-region and covers a small portion of the municipality of Tadó where Oro Legal interventions are unlikely.

Map 7.9 Lower, Middle and Upper San Juan River Sub-region – Protected Areas



Map 7.10 shows that almost the entire area in this sub-region is classified as indigenous and especially Afro-Colombian territories.

Map 7.10 Lower, Middle and Upper San Juan River Sub-region – Ethnic Communities



7.2 Comparative Analysis of Alternatives

This section of the EA is focused on how each of the three proposed alternatives (Alternatives A, B and C) address the five significant issues identified in the Scoping Statement.

- Informality in the possession, use and exploitation of land subject to gold mining.
- Informality in extracting, processing and marketing gold.
- Use of mercury in gold mining processes.
- Income diversification options for ASMs that cannot be legalized and formalized.
- Management of water catchments.

The following tables compare the expected environmental outcomes and the effectiveness of each alternative addressing the significant issues. The comparison is based on an initial evaluation matrix for each alternative, followed by an explanation of the relative values applied, how each alternative responds to each significant issue, and potential impact

(positive or negative). Indirect and cumulative effects were also considered for each of the under each alternative and significant issue. Under Alternative A, the no action alternative, the cumulative negative impacts, both on-site and off-site, could be significant over time as the status quo is maintained. In the case of Alternatives B and C, net cumulative impacts of Oro Legal interventions and proposed mitigation measures are decisively positive in the intervention areas.

Additionally, the direct and indirect impacts of potential mercury release and acacia planting in mine restoration sites occur in specific, separated areas and have a short time duration. As such, it is unlikely that these effects will result in any additionality either among themselves or when considered with other similar actions occurring within targeted water catchments. In other words, if the mitigation measures presented in this document are implemented at the sites where the activities are developed, no cumulative effects are expected.

Table 7-1 Classification of Impact

Value	Impact
0	None
± 1	Low
± 2	Medium
± 3	High
± 4	Very high

Table 7-2 Comparison of Environmental Effects of Alternatives

	NATURAL COMPONENTS								
	Soil	Surface water	Air	Flora	Fauna	Cultural values	Regional economy	Climate change	Total
Alternative A	-2	-3	-3	-2	-2	-1	-1	0	-14
Alternative B	+3	+1 ¹³	+3	+3	+2	+1	+3	+2 ¹⁴	18
Alternative C	+4	+2	+3	+3	+2	+2	+4	+2	22

Table 7-3 Comparison of alternatives

Issues \ Alternatives	Alternative A	Alternative B	Alternative C
Informality in the possession, use, and exploitation of land subject to gold mining	-2	+2	+2
Informality in extracting, processing, and marketing gold	-2	+4	+4
Use of mercury in the gold mining process	-2	+3	+4
Income diversification for ASMs that	0	+2	+3

¹³ Impacts to water resources at, or in near proximity to, the mine site.

¹⁴ Dependent on the amount of CO₂ captured by trees planted or naturally regenerated in restoration sites.

cannot be legalized and formalized			
Management of water catchments	-1	+2	+3
TOTAL	-7	13	16

7.2.1 Informality in the possession, use and exploitation of land subject to gold mining

Alternative A. This alternative does not address the significant issue and does not propose any corresponding mitigation measures. The issues relating to the informal use and possession of natural resources will continue unabated, causing negative environmental, social and fiscal impacts and cumulative impacts whereby environmental problems will accrue with significant cumulative impacts. Deforestation will continue from the illegal sale of wood for structural use within hard rock gold mines mining and clearing of vegetation for informal alluvial gold mining. The deterioration of soils will continue to restrict productive uses and impact watersheds, making local populations that rely on this resource for fishing and water more vulnerable. The absence of state presence will contribute to the precarious security situation and impede the potential significant contribution the gold mining sector could make to the social and economic development of Colombia. Alternative A would result in the status quo or an expansion of informal mining operations should gold prices increase and the effectiveness of law enforcement by the State declines, having increasingly significant cumulative impacts on biodiversity, soils, water quality and quantity, human health and social and economic development.

Alternative B. The potential impacts of rehabilitating degraded, abandoned alluvial-mined lands are decidedly positive compared to Alternative A. Alternative B entails the movement of significant quantities of mine tailings, mostly sand, gravel and, to a lesser degree, soil, to re-contour sites to an approximation of their original topography. In the short term, such work brings associated risks of minimal additional soil erosion and contamination of water resources from sediments and mercury in the soil, but these are significantly outweighed by medium and long term positive impacts as sites are stabilized and ecological and economic functions restored. Individual rehabilitation sites are generally less than 100 ha in total, comprised of individual, non-contiguous properties not larger than 40 ha and averaging approximately 20 ha. The individual properties are separated by remnant native vegetation and unimproved pastures. Since the impacts of rehabilitating degraded areas are minimal, short-term, and localized, cumulative negative impacts are inconsequential, while on-site and off-site cumulative positive impacts will become increasingly significant over time as soils are stabilized and fertility restored, vegetation is reestablished, and ecological functions (hydrological, soil micro fauna and flora, overall biodiversity) are restored over an expanding area. (See photos 7-1 – 7-4.)

Photo 7-1 Typical restoration site with mosaic of native vegetation; Bajo Cauca



Photo 7-2 Typical restoration site with pasture and remnant native tree mosaic; Bajo Cauca



Photo 7-3 Buildup of new O soil horizon and micro-fauna (note fungi) in a four-year-old restoration site planted with *A. mangium*; Bajo Cauca



Photo 7-4 Developing understory of native species in nine-year-old restored site planted with *A. mangium*, Bajo Cauca



Activity interventions are designed to provide miners and landowners with guidance on confirming or securing land tenure to access Oro Legal's assistance to rehabilitate degraded areas. Secure tenure, in turn, will increase the sense of property ownership, encourage a culture of formality in the area, and achieve significant environmental and socio-economic benefits. As these landholdings regain productivity, they will contribute to the region's economic development through new sources of income and creation of jobs. Considering the above, the implementation of Oro Legal will lead to major positive environmental, social, and economic benefits. As with environmental impacts, cumulative economic and social impacts are expected to be positive as property rights are secured with legalization and formalization of mining operations and the productivity of degraded areas is restored.

The following are activities proposed by Oro Legal to address the significant issue:

- Build sustainable capacities for implementation and enforcement of mining regulations.
- Assist MPUs, ASM associations, and Afro-Colombian communities to access formalization programs.
- Strengthen the administrative and technical capacities of miner associations to eventually provide assistance to their members.
- Provide TA in reduced mercury and zero-mercury practices and technologies, improved capture of mercury, and mercury recycling.
- Train and provide TA to MPUs, including support in preparing and implementing PTOs and PMAs.
- Aid the rehabilitation of degraded mining areas.

Alternative C. The activities proposed under this alternative directly address the significant issue identified, incorporating Alternative B, while providing an extended range of options to generate positive environmental, social, and fiscal benefits. As under Alternative B, the cumulative environmental, social and economic impacts will be positive and should expand as more land is rehabilitated over a given region.

7.2.2 Informality in extracting, processing, and marketing gold.

Alternative A. This alternative does not address the significant issue nor propose any type of action to address illegality and informality in the gold mining sector where the Activity will operate. The negative impacts that are attributed to informal gold mining will continue, thus increasing environmental impacts affecting soils, water resources and native vegetation. Informal miners will continue to be subject to safety and occupational health risks. Without proper planning or a business strategy, mining operations will continue to operate inefficiently and generate negative environmental impacts. ASMs will be subject to persecution by authorities with the risk of confiscation of mining equipment and machinery, thus increasing distrust and the risk of conflict, as well as driving illegal operators further towards illegality and possible association with criminal gangs. As with the issue of informality in the possession, use and exploitation of land subject to gold mining described above,

Alternative A would maintain the status quo or possibly exacerbate informality in extracting, processing, and marketing gold and associated negative environmental impacts.

Alternative B. The activities proposed under this alternative directly address this significant issue. One of the main objectives of Oro Legal is to assist ASMs to formalize and legalize their operations with specific contractual targets. Activity strategies are properly focused on alleviating the effects of the significant issue by strengthening the capacities of MPUs to operate legally and adopt a formal business culture with robust environmental and occupational health and safety practices. Similarly, the formalization process will require miners to comply with mining, environmental, labor, tax and royalty regulations. The legalization and formalization of ASMs will lead to a greater presence of authorities charged with overseeing and monitoring activities. Over time, support to formalization will foster an increase in tax and royalty payments, improvements in working conditions, and reduced environmental impact. As legalization and formalization of mining production units expand, positive cumulative environmental, social and economic impacts will accrue with ancillary positive benefits to downstream sites and populations from improved environmental, mining and business practices upstream.

The following activities proposed by Oro Legal directly address the significant issue:

- Strengthen and train mining associations to provide support to their members.
- Advise informal MPUs on the best route to legalize and formalize their operations and support them in this process.
- Advise MPUs in the preparation of PTOs and PMAs.
- Strengthen the Colombian legal framework by working with authorities on streamlining procedures, training staff, and developing resource materials.
- Facilitate the development of operations contracts and formalization subcontracts between informal miners and mining title holders, opening new private options for legalization.
- Develop new responsible routes to market for legal/formal MPUs.

Alternative C. The activities proposed under this alternative are the same as under Alternative B, thus directly addressing the significant issue with the same effect.

7.2.3 Use of mercury in the gold mining process:

Alternative A. This alternative does not address the significant issue, so the use of mercury will continue unabated, causing negative impacts to air quality, water resources, biodiversity, and the health of miners, their families and the public where exposure occurs. The use of mercury will persist, contravening Colombian Law and international treaties to eliminate mercury use in the mining sector by 2018. The cumulative impacts of the status quo will be especially serious to the health of miners and their families as they continue to be exposed to mercury over prolonged periods of time as well as to the environment as mercury continues to enter ecosystems unabated.

Alternative B. The activities proposed under this alternative directly address the significant issue identified. The strategy and activities proposed by Oro Legal have been purposely designed to achieve targets for reducing the use of mercury by ASMs. One of the key strategies to achieve this objective is through operations contracts between small-scale mining and major companies that hold the mining titles and do not use mercury in processing their ore.

The following activities proposed under Alternative B address the significant issue:

- Open pathways to encourage the legalization and formalization of PMUs.
- Broaden BioREDD+/Mining pilot efforts to engage large-scale mining companies in sourcing ore from ASM operators under operating contracts that will lead to higher environmental, social, safety and financial performance, legal compliance and adoption of zero mercury processing methods.
- Provide support in the development of PTOs and PMAs to counter mercury use.
- Use pilots to demonstrate the economic, environmental and health benefits of zero-mercury processing.
- Collaborate with CARs to require gold shops to install simple, locally manufactured stainless steel condensers or retorts to capture mercury vapor and develop protocols for safe handling and disposal of recovered mercury.

Regarding emissions of gaseous mercury, Oro Legal will address this issue by developing protocols to measure mercury concentrations in urban centers in municipalities with a high number of gold shops or processing installations. Gold shops are usually found in commercial areas of small towns which pose a mayor risk for people working in the immediate vicinity and living in surroundings areas. The World Health Organization (2007) considers exposure to an annual average mercury concentration of 0.2 mg/m³ to be tolerable, whereas 1 mg/ m³ or greater is considered hazardous to human health. Raising awareness about contamination levels and exposure and risks to the local population is a key part of this alternative. As the use of mercury is reduced or eliminated in the gold mining process as the proposed activities are implemented over the life of Oro Legal, the net cumulative environmental and health impacts should be positive.

Alternative C. The activity proposed under this alternative directly address the significant issue. Alternative C proposes the same base set of activities as Alternative B. However, these are extended to include a more comprehensive set of best practices to avoid, mitigate or remedy other important environmental impacts attributed to gold mining. The implementation of activities under Alternative C, namely mercury decontamination of ponds formed from abandoned mine sites, would generate potential direct and indirect impacts through the potential exposure to mercury. These would be addressed through the implementation of mitigation measures for each individual site. Since the impacts of decontaminating ponds are minimal, short-term, and localized, cumulative negative impacts are inconsequential. However, direct and indirect cummulative impacts of these actions are consired to be benefificial.

7.2.4 Alternative livelihood for ASM that cannot be legalized and formalized

Alternative A. This alternative neither addresses the significant issue, nor proposes measures for ASMs to consider other economic activities outside the mining sector. Therefore, ASMs that cannot be legalized and formalized will continue to operate illegally with concomitant social, economic and environmental impacts. The development arc of the regions where Oro Legal operates will continue to be highly dependent on the extraction of non-renewable resources and diversification into alternative productive activities based on value-added products other than minerals will be stunted.

The loss of cultural values will be intensified especially in Chocó where a high percentage of the population is Afro-Colombian or of indigenous origin. Despite the fall in gold prices over the last three years, there has been a marked increase in illegal gold mining in the Pacific region possibly due to continued high profitability and the association of illegal mining with money laundering and other criminal activities (Fariñas, 2016). A lack of alternative income options could exacerbate these trends and undermine the integrity of ethnic territories and the local social fabric as illegal mining expands.

Should illegal and informal gold mining continue unabated in the alluvial plains along rivers in Chocó, hydrological functions will be increasingly affected where the cumulative threat of serious flooding to downstream communities will be a recurrent and growing risk, water supplies will be irreparably contaminated, and local fisheries degraded, leading to food insecurity, deterioration of health conditions, and loss of livelihoods.

Alternative B. The activities proposed under this alternative address the significant issue, specifically in relation to outcomes expected under Objective 2 of Oro Legal. The strategies and activities proposed are purposely designed to provide ASMs that cannot be legalized with viable income diversification activities based on high-value tree crops grown under agroforestry systems, reforestation, plantation management and associated apiculture activities related to restoration efforts, and livestock production under silvopastoral systems. These alternative economic activities have proved to be technically accessible and attractive to traditional communities and have garnered strong local support.

The establishment of regional value chains for products with existing demand in domestic markets and export potential in regional or international markets, which generate sustainable income for the farmers, could give rise over the medium term, to a “critical mass” that would be sufficient to attract other marginalized illegal miners, lead to formation of vigorous producer associations, open access to credit, make investments in local value-added processing feasible, and spur authorities to improve local infrastructure to support the value chains. The cultivation of tree crops and raising livestock under such systems, in turn, could

lead to the conservation of ecosystems and water resources and other positive environmental, social and economic impacts.

The following activities proposed by Oro Legal address the significant issue:

- Planting of annatto under agroforestry systems.
- Establishment of agro-silvopastoral systems in Antioquia, paired with good practices such as cover crops to enhance the texture and fertility of soils, forage crops, live fencing, improved pasture grasses, and rotational grazing.
- Expansion of honey production and diversification of production into other derivatives like pollen, propolis, and royal jelly.
- Significant expansion of reforestation activities to restore degraded sites.
- Local value-added processing.
- Expansion of markets.
- Opening access to investment capital through credit facilities and partnerships.

The development of income diversification activities for ASM families based on small-scale agroforestry, silvopastoral and reforestation present a low to moderate potential risk of generating negative impacts. The Environmental Mitigation Approach (EMA) in Section 8 addresses the risk of potential negative impacts, both at a site-specific level as well as cumulative impacts over time. These impacts include:

- Land use changes leading to clearing of forests and riparian vegetation.
- Pressure on nearby protected areas and attendant biodiversity.
- Soil erosion from poor agricultural practices.
- Contamination of waterways and health hazards from pesticide and fertilizer use.
- Increase in agricultural pests.

Alternative C. The activities proposed under this alternative address the significant issue, specifically with respect to the outcomes expected from Oro Legal, Objective 2. As with Alternative B, informal miners would have alternative economic income sources other than mining. However, Alternative C proposes a broader group of alternative economic activities based on tree crops (cacao, rubber and naidí), aquaculture in small-scale fish ponds within and outside of mining sites and intensification of cattle farming under agro-silvopastoral systems (in Antioquia only).

The promotion of a wider range of alternatives under Alternative C could have a greater impact on livelihoods compared to Alternative B; nevertheless, the value chain of each additional productive activity presents a distinct set of challenges, opportunities and environmental issues that could disperse efforts and overstretch project resources. Many of the same potential short-term, site-specific and cumulative negative impacts identified in Alternative B apply to Alternative C as well, and would be similarly addressed by the measures included in the EMA in Section 8 of the EA. If small-scale aquaculture were promoted as an alternative, strict attention would need to be given to water quality and

mercury contamination, with careful monitoring of possible bioaccumulation of mercury in fish, activities that would overly tax the technical and budgetary capacity of Oro Legal.

7.2.5 Management of water catchments

Alternative A. This alternative neither addresses the significant issue nor proposes measures for improving water quality in water catchments and systems in selected municipalities. Some municipal water systems can have restricted distribution systems, intermittent service and old, poorly maintained facilities where monitoring of physio-chemical parameters is suboptimal, conditions that would continue under Alternative A. Where Oro Legal operates, most water catchments that supply municipal water systems have been considerably altered by land use change from forest cover to agriculture and extensive livestock production, human settlements and mining with attendant discharge into water courses of animal and human waste, sediments, chemicals and heavy metals. Under Alternative A, degradation water catchments and water supplies would continue unchanged along with associated negative environmental, social and economic impacts, resulting in increasingly detrimental accumulative impacts over time.

Alternative B: The activities proposed under this alternative address the significant issue as part of Oro Legal's overall design and objective is to strengthen management and conservation of water catchments that supply drinking water to urban populations. An important aspect of this support is to increase the capacity of municipal authorities to plan, implement and develop sustainable funding streams. Direct, indirect and cumulative impacts associated with these activities are similar in nature and scope to those listed in the alternative livelihoods section above. The Environmental Mitigation Approach (EMA) in Section 8 addresses the risk of potential negative impacts, both at a site-specific level as well as cumulative impacts over time.

Alternative C: The activities proposed under Alternative C address the purpose and need regarding water catchments. Alternative C includes the actions proposed under Alternative B, complemented by the following additional interventions that Oro Legal could assume:

- Directly contribute to reforestation and watershed restoration activities in select water catchments apart from areas degraded by mining
- Support design and implementation of financial mechanisms based on payment for water-based ecosystem services
- Regeneration of degraded soils with fast-growing, economically valuable cover crops, specifically vetiver, which has the advantage of absorbing heavy metal as well as to develop this option, it will be necessary to conduct studies to identify the amount of mercury that could be bio-accumulated by vetiver and mobilization along the food chain.

- Support design and implementation of financial mechanisms based on payment for water services.
- Carry out environmental education campaigns targeted at urban residents living in proximity to water course and intakes with the goal of preventing the disposal of solid and liquid waste in water courses and promoting the conservation of micro-watersheds that supply water to local aqueducts.

Alternative C would more directly mitigate critical factors contributing to poor quality of water with marginally higher levels of positive environmental, economic and social outcomes and cumulative impacts, but at higher cost.

Direct, indirect and cumulative impacts associated with these activities are similar in nature and scope to those listed in the alternative livelihoods section above. The presented in Section 8 addresses the risk of potential negative impacts, both at a site-specific level as well as cumulative impacts over time.

7.3 Selection of the Recommended Alternative

Alternative C will have the most positive impact on the five significant issues identified. However, implementation of all activities proposed under Alternative C would involve actions and significant additional costs that: (i) are unavailable at present within the existing Oro Legal budget and (ii) could potentially disperse effort and compromise the achievement of the “future desired condition” and main objectives of Oro Legal.

Alternative B is the best fit to address the five significant issues in a comprehensive manner and within the five-year timeframe and budget allocated for implementation of Oro Legal and thus more viable for the fulfillment of the “desired future condition” over the medium term. Alternative B considers lessons-learned and will build on the momentum and achievements from BioREDD+/Mining that will be amplified by a broader coalition of strategic partners. This should not be surprising since the anticipated impacts of Oro Legal interventions are largely positive to the extent that the “desired future condition” of the entire Activity *per se*, is a positive condition where environmental, social, labor and economic conditions show considerable improvement.

Both Alternative B and Alternative C would implement a range of activities designed to mitigate the adverse impacts of gold mining; however, the suite of actions proposed under Alternative B, though less comprehensive than Alternative C, are judged to have a higher probability of success within the Activity’s current period of performance and budget. Nonetheless, Alternative C offers several actions that would not have significant cost implications and could be developed within the Activity’s timeframe and budget, specifically:

- Payment for ecosystem services by expanding the water fund initiative.
- Intensification of livestock production under silvopastoral systems in water catchments (Antioquia only).

- Promote other selected agroforestry crops where value chains are already established and counterpart funding can be leveraged from public and private sector partners.
- Use vetiver to recover degraded areas.
- Carry out education campaigns with municipal authorities to reduce the discharge of solid waste and liquid waste into waterways that supply municipal water systems and promote watershed conservation.

Based on the comparative analysis of the alternatives, the authors of the EA recommend Alternative B (actions proposed by Oro Legal) complemented by the additional initiative above be approved as the preferred alternative. This can be considered “Alternative B+”.

8. ENVIRONMENTAL MITIGATION APPROACH

The Preferred Alternative for Oro Legal includes measures that will be incorporated into implementation of the Activity to avoid or mitigate potential negative impacts and enhance overall outputs. The set of interventions proposed under the two main components of the Activity are in many cases mitigation measures in and of themselves, or will yield positive outcomes and were purposely designed to improve water quality, reduce mercury contamination, rehabilitate degraded areas, secure sustainable water supplies for municipal urban areas, and offer alternative incomes to ASM communities. These contractual interventions and standard operating procedures already in place form the backbone of the proposed Environmental Mitigation Approach (EMA) complemented by other measures to address specific risks across the range of activities grouped in 10 categories or areas to be implemented under the Activity as shown in Table 8-1.

Table 8-2 presents the 28 mitigation measures for the EMA with details on responsible parties, indicators, monitoring method and the estimate cost associated with carrying out each measure (over and above that which is already contemplated under the Activity design). Priority is given to preventative measures that may modify, or in some cases, defer proceeding with a proposed activity; for example, identifying a new location or changing the design of a demonstration zero-mercury processing pilot plant or prohibiting Activity interventions in forest reserves established under Law 2/1959 or other protected areas. Other measures aim to manage potential risks such as monitoring gaseous mercury around gold shops and in areas frequented by Activity and implementing partners' staff and limiting their exposure. The Activity will also take proactive measures to generate positive environmental outcomes. This is the case of post-mining rehabilitation investments to kick-start long-term natural processes for restoring ecosystem functions or support to municipalities in IWRM in water catchments that supply local drinking water systems.

Table 8-I Summary of Potential Impacts and Mitigation Measures

Activity Categories	Potential Negative Environmental Impacts	Mitigation Measures
ASM gold production	ASM gold production carried out without mining titles and with minimum or with no environmental, industrial and social mitigation practices to reduce potential impact may lead to negative effects on, water, soil, air, biodiversity and human health.	<ul style="list-style-type: none"> • Provide TA to strengthen MPUs in the legalization and formalization process in compliance with environmental, labor, safety, and fiscal requirements. • Collaborate with the MME and MADS to design/modify policies and procedures to expand and expedite legalization and formalization, including granting and monitoring Environmental Licenses that require PMAs and PTOs. • Train MPUs in environmental, labor and safety regulations and improved practices. • Link MPUs to new responsible routes to market. • Provide technical assistance to MPUs on environmental management of their operations, including wastewater contamination. When possible OL will support the MPUs to prepare requests for global environmental licenses as part of their formalization process, including water use and disposal permits.
Use of mercury by ASMs	The use of mercury by ASMs leads to negative impacts on physical resources (soil, water and air), biological resources (flora and fauna) and human health (especially children and pregnant women).	<ul style="list-style-type: none"> • Promote the use of technically and financially appropriate zero-mercury gold processing technologies and improved capture and reuse processes. • Facilitate financial mechanisms to underpin the introduction of zero-mercury technology. • Facilitate operating contracts between ASMs and private mining companies that do not use mercury to process gold. • Provide MPUs with information and guidance on proper disposal of mercury residues and hazardous waste, in accordance with best practices and Colombian law.
Restoration of areas degraded by mining	Restoration activities can lead to short term negative impacts to water quality and soils and may be less effective if not well planned and executed	<ul style="list-style-type: none"> • Prepare simple restoration plans for each site that include: confirmation of land tenure (communal or individual) and compliance with legal restrictions (e.g., Law 2/1959; protected areas); layout of recontouring operations and planting sites; agreements among parties for implementation and long-term management of plantations and naturally regenerated trees; limiting earth-moving to the minimum necessary to reduce soil erosion and impacts to waterways and prepare the site for planting; protection of any existing native

Activity Categories	Potential Negative Environmental Impacts	Mitigation Measures
		vegetation; proper siting of refueling and maintenance areas when heavy machinery is used.
Implementation of income diversification options	The promotion of income diversification options has the potential to: (i) change land use and ecosystems caused by land degradation due to: erosion from poor agricultural practices, invasion of protected or sensitive areas, and contamination from agriculture run off and (ii) cause deforestation when natural ecosystems are subjected to tree felling to carry out productive activities.	<ul style="list-style-type: none"> • Ensure Oro Legal interventions avoid any conversion of forests to agriculture. • Prohibit the development of income diversification activities within 500 meters of sensitive ecosystems or buffer zones of protected areas • Include training on ecosystem services provided by forests and potential negative impacts from agriculture. • Promote good agricultural practices: minimal or zero tillage, contour planting, and crop rotation to improve soil fertility and prevent pest outbreaks. • Train Oro Legal and partner staff on USAID environmental guidelines for conservation agriculture and smart-climate agriculture. The guidelines are available in: http://www.usaidgems.org/Sectors/agriculture.htm
Management of fertilizers	The use of inorganic fertilizers has the potential for: (i) contamination of surface and underground water bodies due to runoff from harvesting, which can transport nitrates that cause eutrophication and depletion of oxygen in rivers and lakes; (ii) erosion and degradation of soil, due to the change in soil's chemical structure, which would affect its fertility in the long run, and (iii) changes in land use and ecosystems, as harvest production increases due to the use of fertilizers.	<ul style="list-style-type: none"> • Use only organic fertilizers purchased with USAID funds in accordance with the Oro Legal waiver for purchase of fertilizers received in May 2016. • Promote the use of organic fertilizers in accordance with the needs of the crops and the physical and climate characteristics of the zone. • Train farmers on safe storage, use and disposal of inorganic fertilizers.
Management of pesticides	The use of synthetic pesticides has the potential of: (i) expanding agricultural boundaries; (ii) contaminating surface and underground water bodies caused by pesticides runoff; (iii) creating resistance of pests to the pesticides; (iv) affecting farmers' health, derived from inhalation/ingestion/skin absorption of pesticides; (v) generating hazardous solid waste due to poor disposal of packages or containers, or inadequate pesticide storage.	<ul style="list-style-type: none"> • Where pesticides are to be used, apply measures required by the Pesticide Evaluation and Action Plan for Safer Use – PERSUAP approved by USAID/Colombia, which includes crops that will be promoted by Oro Legal. • Train farmers on storage and use of chemical pesticides including: <ul style="list-style-type: none"> - Definition of the pesticides that can be used with different crops. - Appropriate use, dosage and application of pesticides - Appropriate storage and disposal of pesticides and containers. (e.g. "Triple Rinse" method for cleaning of containers)

Activity Categories	Potential Negative Environmental Impacts	Mitigation Measures
Origen of seeds	Using imported or non-locally sourced seeds may lead to: (i) reduced resistance to pests, diseases or weather conditions in the region; (ii) contamination of surface water bodies and soil degradation as an indirect effect of the application of fertilizers and pesticides in amounts greater than those used for endemic seeds; (iii) reduced availability of native seed, and (iv) increased dependence of farmers on imported seeds, fertilizers and pesticides required for agricultural production.	<ul style="list-style-type: none"> • Use only seeds purchased with USAID funds in accordance with the Oro Legal waiver for purchase of fertilizers received in May 2016. • Promote the use of locally sourced seeds and plant material. • When using imported seeds consider environmental criteria in the selection of varieties, such as: suitability to local soil and ecological conditions, water and fertilizer demand, resistance to and control of pesticides.
Transformation of agricultural products	Transformation of agricultural products have the potential to generate solid waste or by-products that could cause soil and/or water contamination if not properly disposed of.	<ul style="list-style-type: none"> • Train producers in sound post-harvest and transformation techniques, including handling and disposal of solid and liquid waste in accordance with USAID environmental guidelines (link: http status of://www.usaidgems.org/mse/foodProcessing.htm) • Promote good industrial practices for storage, cleaning and control of waste for the production and transformation of value added products.
Support for improvement of water catchment, treatment, and storage systems.	Attempts to improve water catchments, treatment and storage systems, has the potential of promoting: (i) poor execution of proposed solutions/designs due to the lack of municipal or departmental resources and/or political will, and (ii) short to medium-term deterioration of the proposed solutions/designs due to a lack of maintenance, equipment, supplies, or trained staff. Both have impacts on water quality and human health.	<ul style="list-style-type: none"> • Assist local water companies to improve reporting under the Single Public Utilities Information System – SUI. • Support, together with departmental and local environmental authorities, mayors and governor’s offices, in Integrated Water Resource Management (IWRM), in accordance with available watershed management and land use planning instruments.
Risks of mercury exposure for Oro Legal staff, partners and beneficiaries	The work performed in the municipalities prioritized by Oro Legal without protection or mitigation measures against mercury on the environment, has the potential of negatively impacting the health of Oro Legal staff, its implementing partners, and its beneficiaries.	<ul style="list-style-type: none"> • Avoid performance of activities in places with known mercury contamination and/or limit exposure times to the minimum extent possible. • Locate Oro Legal field offices and visitor accommodation away from sources of high atmospheric mercury concentration (gold shops, rustic processing plants, etc.). • Train Oro Legal staff, implementing partners and key beneficiary groups in the risks of exposure to mercury, avoidance measures and use of personal protection equipment. • Broad dissemination of the results of mercury monitoring conducted by Oro Legal to key stakeholders.

Table 8-2 Environmental Mitigation and Monitoring Plan

Activity Categories	Mitigation Measures	Responsible Entity	Monitoring Method			Estimated costs ¹⁵ US\$
			Monitoring Indicator	Methods	Monitoring Frequency	
ASM gold production	Mitigation measure 1 Provide TA to strengthen MPUs in the legalization and formalization process in compliance with environmental, labor, safety, and fiscal requirements	Oro Legal	Number of MPUs legalized Percentage of MPUs formalized	As per approved M&E plan	Quarterly	Core program activity
	Mitigation measure 2 Collaborate with the MME and MADS to design/modify policies and procedures to expand and expedite legalization and formalization, including granting and monitoring Environmental Licenses that require PMAs and PTOs.	Oro Legal, MME and MADS	Number of MPUs legalized Percentage of MPUs formalized	As per approved M&E plan	Quarterly	Core program activity
	Mitigation measure 3 Train MPUs in environmental, labor and safety regulations and improved practices	Oro Legal	Number of people trained Number of MPUs adopting improved, sustainable practices	As per approved M&E plan	Quarterly	Core program activity
	Mitigation measure 4 Link MPUs to new responsible routes to market	Oro Legal	Number of MPUs benefitting from new, responsible routes to market	Project and certification program records	Annually	\$25,000
Use of mercury by ASMs	Mitigation measure 5 Promote the use of technically and financially appropriate zero-mercury gold processing technologies, and improved	Oro Legal	Quantity of mercury used to produce 1 gram of gold by MPUs supported by Oro Legal	As per approved M&E plan	Annually	Core program activity

¹⁵ Excludes core project activities.

Activity Categories	Mitigation Measures	Responsible Entity	Monitoring Method			Estimated costs ¹⁵ US\$
			Monitoring Indicator	Methods	Monitoring Frequency	
	capture and recycling processes.		Reduction of mercury released to the environment (in Metric Tons) Percentage reduction of airborne mercury emissions from stakeholders supported by Oro Legal			
	Mitigation measure 6 Facilitate financial mechanisms to underpin the introduction of zero-mercury technology.	Oro Legal, implementation partners	Percentage reduction of airborne mercury emissions from stakeholders supported by Oro Legal Quantity of mercury used to produce 1 gram of gold by MPUs supported by Oro Legal	As per approved M&E plan	Annually	Core program activity
	Mitigation measure 7 Facilitate operating contracts between ASMs and private mining companies that do not use mercury to process gold.	Oro Legal, implementation partners	Quantity of mercury used to produce 1 gram of gold by MPUs supported by Oro Legal	As per approved M&E plan	Annually	Core program activity
Restoration of areas degraded by mining	Mitigation measure 8 Prepare simple restoration plans including the information mentioned in Table above	Oro Legal, implementation partners	Number of hectares of land degraded by mining rehabilitated	As per approved M&E plan	Quarterly	Core program activity

Activity Categories	Mitigation Measures	Responsible Entity	Monitoring Method			Estimated costs ¹⁵ US\$
			Monitoring Indicator	Methods	Monitoring Frequency	
	(Potential Impacts and Mitigation measures)					
Implementation of income diversification options	Mitigation measure 9 Ensure Oro Legal interventions avoid any conversion of forest to agriculture.	Oro Legal	Forest area converted to agriculture	GIS mapping Field monitoring	Annually	\$10,000
	Mitigation measure 10 Prohibit the development of income diversification activities within 500 meters of sensitive ecosystems or buffering areas to protected zones.	Oro Legal	Income diversification activities established within 500 meters of sensitive ecological areas or protected areas.	GIS mapping Field monitoring	Annually	\$10,000
	Mitigation measure 11 Include training on ecosystem services provided by forests and potential negative impacts from agriculture.	Oro Legal	Number of people trained	Field monitoring	Annually	\$10,000
	Mitigation measure 12 Promote good agricultural practices: minimal or zero tillage, contour planting, and crop rotation to improve soil fertility and prevent pest outbreaks.	Oro Legal	Number of hectares under improved management	As per approved M&E plan	Quarterly	Core program activity
	Mitigation measure 13 Train Oro Legal and partner staff on USAID and developmental guidelines for conservation agricultural and smart-climate agriculture.	Oro Legal	Number and percentage of Oro Legal and implementing partner staff trained	Attendance records	Semi-annual	\$10,000
Management of fertilizers	Mitigation measure 14 Use only organic fertilizers purchased with USAID funds in accord with the Oro Legal fertilizer waiver of May 2016.	Oro Legal	Amount of organic fertilizer purchased under AF instruments	Project records	Annually	0

Activity Categories	Mitigation Measures	Responsible Entity	Monitoring Method			Estimated costs ¹⁵ US\$
			Monitoring Indicator	Methods	Monitoring Frequency	
	Mitigation measure 15 Promote the use of organic fertilizers in accordance with the needs of the crops and the physical and climate characteristics of the zone.	Oro Legal	Number and percentage of farm families properly utilizing inorganic fertilizers	Project records Field monitoring	Quarterly	\$5,000
	Mitigation measure 16 Train farmers on safe storage, use and disposal of inorganic fertilizers.	Oro Legal	Number of people trained Number and percentage of farm families properly utilizing inorganic fertilizers.	As per approved M&E Plan Project records	Quarterly	\$20,000
	Mitigation measure 17 Where pesticides are to be used, apply measures required by the Pesticide Evaluation and Action Plan for Safer Use – PERSUAP approved by USAID/Colombia, which includes crops that will be promoted by Oro Legal.	Oro Legal	Action taken as required	Field monitoring as per approved PERSUAP	Annually	0
Management of pesticides	Mitigation measure 18 Train farmers on storage and use of chemical pesticides including: - Definition of the pesticides that can be used with different crops. - Appropriate use, dosage and application of pesticides - Appropriate storage and disposal of pesticides and containers (e.g. Triple Rinse” method for cleaning of containers).	Oro Legal	Number of people trained Number and percentage of farm families properly utilizing inorganic pesticides	As per approved M&E plan Field monitoring	Quarterly	To be determined

Activity Categories	Mitigation Measures	Responsible Entity	Monitoring Method			Estimated costs ¹⁵ US\$
			Monitoring Indicator	Methods	Monitoring Frequency	
Origin of seeds	Mitigation measure 19 Promote the use of locally sourced seeds and plant material.	Oro Legal	Origin and characteristics of seeds	Project procurement records	Annually	Standard operating procedure
	Mitigation measure 20 In accordance with the waiver, when using imported seeds consider environmental criteria in the selection of varieties, such as: suitability to local soil and ecological conditions, water and fertilizer demand, resistance to and control of pesticides.	Oro Legal	Origin and characteristics of imported seeds	Project procurement records	Annually	Standard operating procedure
Transformation of agricultural products	Mitigation measure 21 Train producers in sound post-harvest and transformation processes, including handling and disposal of solid and liquid waste, in accordance with USAID environmental guidelines.	Oro Legal producer associations	Number of people trained Number and percentage of producers and transformation centers applying USAID guidelines	Project records Field monitoring	Annually	\$20,000
	Mitigation measure 22 Promote good industrial practices for storage, cleaning and control of waste for the production and transformation of value-added products	Oro Legal, Grantees (i.e.: associations, CCs)	Number and percentage of producers and transformation centers applying USAID guidelines	Project records Field monitoring	Annually	\$20,000
Support for improvement of water catchment, treatment	Mitigation measure 23 Assist local water companies to improve reporting under the Single Public Utilities Information System – SUI.	Oro Legal	Number of water companies with improved reporting on water quality and balances	Project records	Annually	\$10,000
	Mitigation measure 24	Oro Legal	Number of IWRM	As per approved	Annually	Core

Activity Categories	Mitigation Measures	Responsible Entity	Monitoring Method			Estimated costs ¹⁵ US\$
			Monitoring Indicator	Methods	Monitoring Frequency	
	Support, together with departmental and local environmental authorities, mayors and governor's offices, Integrated Water Resource Management (IWRM), in accordance with available watershed management and land use planning instruments.		plans or actions implemented	M&E Plan		program activity
Risks of mercury exposure for Oro Legal staff, partners and beneficiaries	Mitigation measure 25 Avoid performance of activities in places with known mercury contamination and/or limit exposure times to the minimum extent possible.	Oro Legal	Time spent in places contaminated with mercury, limiting exposure times as per WHO recommendations	Atmospheric mercury testing Site visit logs	Monthly	Standard operating procedure
	Mitigation measure 26 Locate Oro Legal field offices and visitor accommodation away from sources of high atmospheric mercury concentration (gold shops, rustic processing plants, etc.).	Oro Legal	Location of field offices	Maps, cross-referenced with mercury contamination data	At office opening or subsequent change in location	Standard operating procedure
	Mitigation measure 27 Train Oro Legal staff, implementing partners and key beneficiary groups in the risks of exposure to mercury, avoidance measures and use of personal protection equipment.	Oro Legal	Number and percentage of Oro Legal implementing partner staff and key beneficiaries trained	Project records Field monitoring	Quarterly	\$5,000
	Mitigation measure 28 Broad dissemination of the results of mercury monitoring conducted by Oro Legal to key stakeholders.	Oro Legal	Number of recipients of mercury communication strategy	Project records	Yearly	\$12,000

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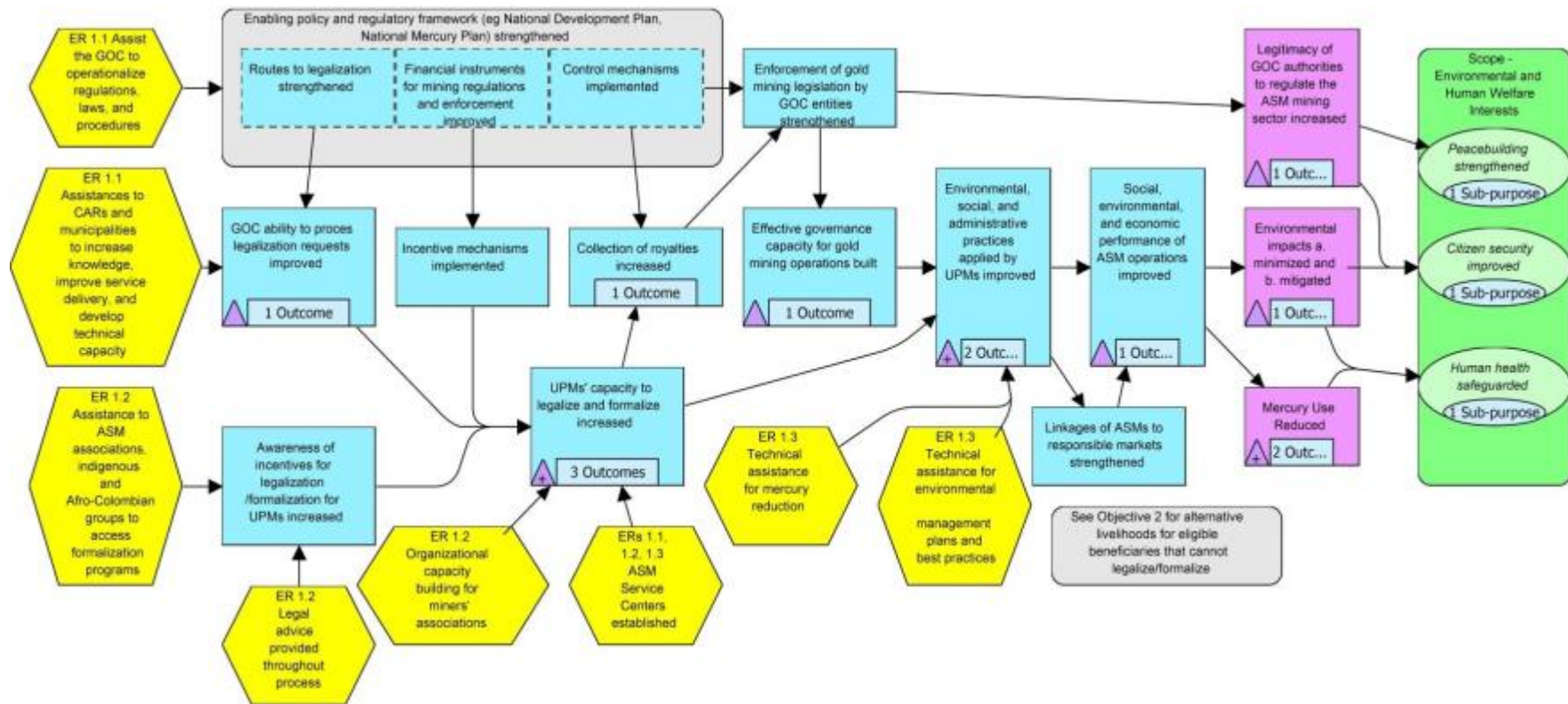
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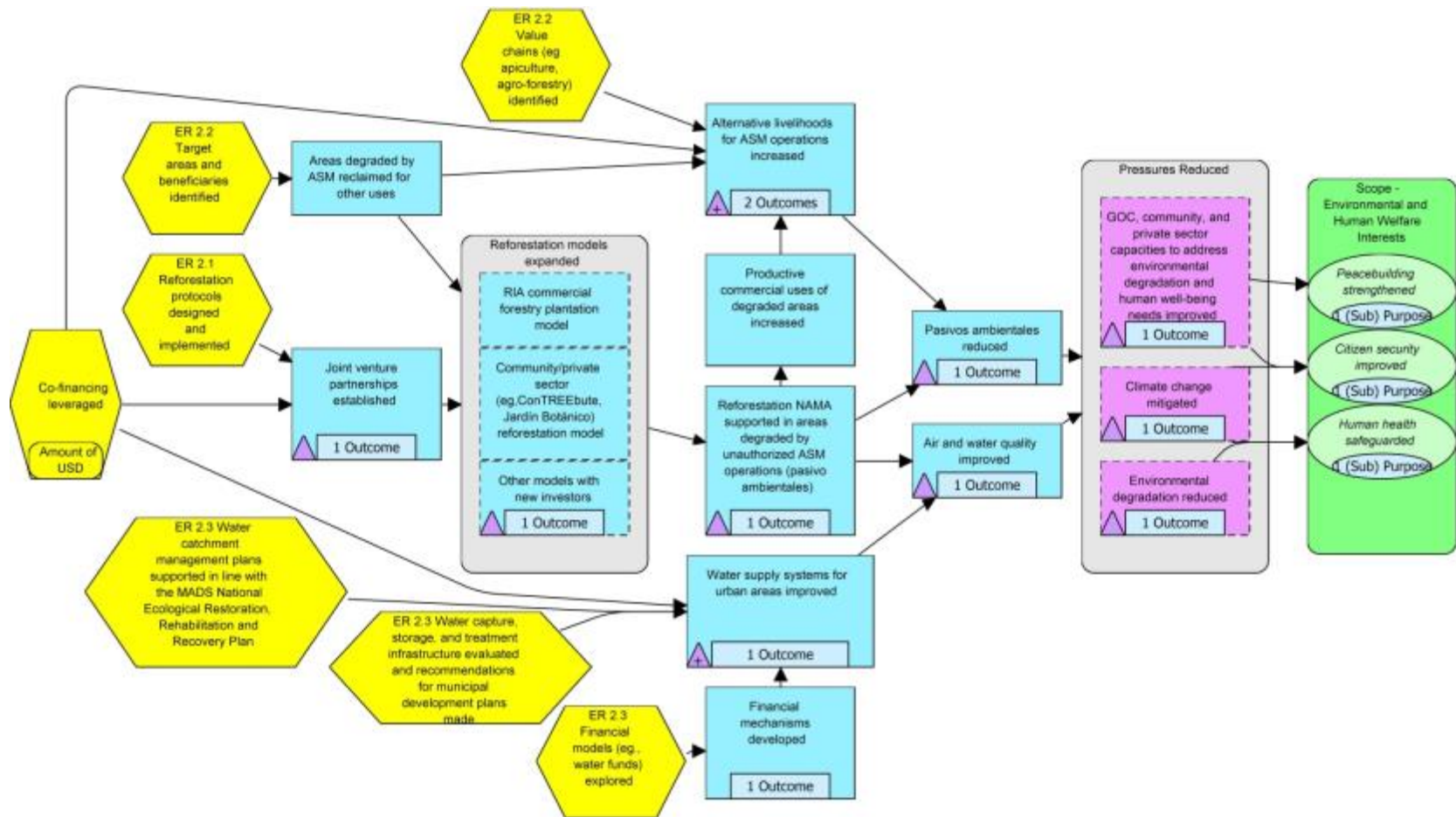
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Annex I Oro Legal preliminary theory of change for objective I



Annex I Oro Legal preliminary theory of change for objective 2



ANNEX 2. Environmental and Socioeconomic Characterization of the Area of Influence

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The Oro Legal project carries out its activities in the departments of Antioquia and Chocó. Before conducting an environmental assessment of its activities and their potential impact in the regions where there will be presence of the program, a brief social characterization of the area of influence of the Oro Legal program and an environmental and socioeconomic characterization of each sub-region are presented.

I SOCIAL CHARACTERIZATION

1.1 Values and cultural dynamics against mining activity

Artisanal mining is a traditional and ancient practice in most of the departments of Colombia, especially in Chocó. Many communities have conducted it for considerable periods, and therefore this economic activity is part of their cultural practices and livelihoods to fight poverty. However, the expansion of mining has led to changes in the cultural dynamics in the areas where gold resources are found, manifested by the weakening of the social structure, loss of cultural values, increase in conflict, violence, corruption and inequity in gender relations.

According to INDEPAZ, in the Colombian Pacific has existed artisanal mining or subsistence mining, linked to other forms of life: agriculture, fishing and harvesting. Ancestral mining makes a constituent part of the culture and identity of people of this region and it is a way of generating income that has remained through the centuries as a productive tradition of high symbolic value in these communities.

During the interviews application in Chocó, many leaders have stressed the predominant mining vocation in their territories; however, their visions of development are conditioned by the uncertainty of the depletion of mineral reserves. In response, many of the interviewees indicated the need to strengthen the mining industry with more capital, formalization and technology to continue the use of resources, while greater impact productive projects are promoted. Only in one particular case, a leader stated they no longer find gold prospects and the need to promote other productive vocations.

The lack of control, poor geographical accessibility of the mining development areas and the weak state presence bring on the entry of illegal armed actors that promote violence and insecurity. According to the INDEPAZ study, some illegal mines are conformed or set up specifically to launder money from illicit drug or trafficking activity, and in that dynamic, illegal armed groups protect the forest corridors through which drugs are moved. On the other hand, due to the circulation of money by buying and selling gold, robberies, extortions and presence of narco-paramilitary groups are presented, providing security to miners and owners backhoes.

The role of armed groups has not been restricted to the safety of miners to prevent robberies and extortions, but also perform control over agents that could threaten the business. In addition, regarding the interviews during the fieldwork, several leaders have said they are limited and intimidated for carrying out their work of control and protection of the territory because of the risks that would entail for their personal integrity.

Along with the conflict, communities suffer processes of family and social disintegration and the loss of traditional values. With the application of in-field interviews, it has been detected discontent of many community leaders about the consequences of mining in their communities, promoting family disagreements, disrespect to the properties of neighbors and relatives, little or no value on verbal agreements and honor, and the loss of ancestral values of coexistence. All this would be due to the presence of migrants and pressure for access to the mineralized zones.

At the same time, corruption has spread throughout all the territories involving in mining activities and affecting people, community leaders and authorities. Heavy machinery reaches all places where a gold mine exists, passing through checkpoints where a kind of toll is paid to all stakeholders in order to travel there. INDEPAZ has also identified the form of "weight mining" to the community, with the purpose of obtaining the "authorization" for the activity. Some interviewees have also indicated the complicity of community leaders and environmental authorities in the destruction of the territory by mining.

The effects of indiscriminate exploitation and illegal gold mining have also affected family relationships and gender equalities. According to INDEPAZ, territories of Afro-Colombian communities are threatened, particularly, barequeras women who have been deprived of their livelihoods and have lost their autonomy. This situation is highly risky in these communities where women traditionally represent the authority axis on which turns the family life and are those who remain in their homes to ensure social reproduction on a daily basis, given the high absenteeism of male figure. In this regard, some of those interviewee during the fieldwork, noted with concern the increase in single parent households headed by women, who are in a vulnerable situation.

1.2 Social problems derived from environmental impacts of the informal gold mining

There is a set of common environmental impacts that leaves the informal gold mining in areas where it operates. These have to do with deforestation, ecosystems degradation, affectation of water sources and streams, soil contamination, topsoil detriment, affectation of flora and fauna, among others. From the information reviewed and applied in-field

interviews, we have identified areas of concern among representatives of ethnic communities facing threatening situation to health and safety of communities.

Regarding to deforestation and modification of riverbeds, communities become more vulnerable in the event of disasters caused by climate change. The number and size of fish that can still be found, has decreased and its food quality is impaired by the presence of mercury. This creates a high risk of displacement due to the lack of production alternatives with the present contamination in the water (INDEPAZ, 2013).

Finally, several interviewed stakeholders referred to the consequences of mining operations on collective territories, especially soil degradation and deforestation. In interviewees' word, mining "has devastated" conservation areas and planting crops for food crops and productive initiatives. This being so, they are losing food sovereignty and different economic development or complementary alternatives to mining.

2 BAJO CAUCA

2.1 General aspects

The Bajo Cauca region is located in Northeastern Antioquia, and it comprises nine sub-regions that make up the department. The Bajo Cauca extends over 8,485 km², according to the census of 2007, with a population adding up to 255,242 inhabitants. It is made up of the municipalities of Caucaasia, El Bagre, Nechí, Tarazá, Caceres and Zaragoza.

This sub-region is located in the foothills of the Central Mountain Range, between the mountainous areas of Ayapel and San Lucas, over the basin of the Cauca and Nechí rivers. Mining is the most important activity of its economy and, in fact, the region was subjected to populating processes because of this practice. Other economic activities include fishing, agriculture and livestock farming.

2.2 Environmental Characterization

- **Water resources**

Major rivers in the sub-region of the Bajo Cauca Antioqueño are Cauca and Nechi. Both rivers run from South to North, in the municipality of Nechí, where the Nechi River joins the Cauca River.

The Cauca River extends over 140 km, and its channel has created a large valley of floodable plains. Its main tributaries are the Pescado, Rayo, Tarazá and Man rivers.

The Nechí River is second in importance in the Bajo Cauca sub-region, which runs on its Eastern side, continuing in a South-North direction. This river forms a large valley of flooding plains of great importance for the region because of its traditional gold producing potential. The main tributaries of the Nechi River are the San Pedro stream and the Amacerí, Tigüi, El Bagre, Zaragoza and Cacerí rivers.

The Bajo Cauca sub-region has over 70 marshes in 25 complexes, which cover an area of approximately 40,000 ha, and are located in the alluvial plains of the Cauca, Man and Nechí rivers.

Table 2-1 Main Marshes in the Bajo Cauca

Location	Name
Man river plain	Ciénaga Colombia, Mateguadua, El Sabalito
Cauca river plain	Hoyo Grande, El Palmar, La Gitana, El Olvido, El Limón, Margento, Piñalito, Servia, Palanca, La Envidia, El Paraiso, El Billete, Afuera, San Lorenzo
Nechí river plain	Ciénaga Grande, Corrales, El Sapo, Bijagual, Marimona, palizada, La Paja, Aguas Prietas, Las Delicias, Don Alonso, La Guajira, San Carlos, El Garreto, La Llana, Pujador, Las Palomas, Tosnovan, Sabalito, Portugal, El Gringo

Source: Planeación Ambiental Corantioquia, 2006. Adapted by INERCO Consultoría Colombia, 2016.

The Bajo Cauca alluvial deposit aquifers are associated with recent alluvial deposits from the first currents and their tributaries, as well as higher and lower members of the Cerrito (Palacio and Betancourt, 2007) sedimentary formation. In the Bajo Cauca zone, underground water is the main water supply source for human consumption in the rural area.

Corantioquia carried out a water inventory of the sub-region in 2005, identifying 1,927 water points, 1,837 wells, 70 water holes and 20 springs in the sub-region. It was also determined that, out of 20 watershed identified for aqueduct supply, only 4 have good quality water, 8 with fair quality and 8 with poor quality.

Average coverage of aqueducts corresponds to nearly 80% of urban zones. Out of all the municipalities, El Bagre is the only municipality lacking potable water treatment.

- **Relief and soils**

Topography of Bajo Cauca starts from the scarped stream in the South, to slightly hilly or flat land in the North, ranging between a strongly undulated hilly system, interbedded with isolated plains and some alluvial terraces.

The internal drainage ranges from good to poor. In some areas, it is poor due to the presence of hardened layers, distributed in an irregular form as regards depth and thickness. They are of a brown color with grey streaks, depth ranging between 0.2 m. and 4.8 m. and thickness between 0.4 and 2.5 m. They are arranged as ribbons that appear and disappear through the soil horizon.

Texture varies from clayey, in some rough areas, to sandy in the alluvial areas of influence, even though the predominant textures fluctuate between loamy-clayey-sandy and loamy. Infiltration ranges from very slow to fast because of the loam-clayey-sandy content, the clay or the presence of hardened layers in many areas, predominating slightly low.

The water holding capacity is generally low even though there are some areas with soils that have a good water holding capacity, mainly those in areas covered with primary forest. Soils show different erosion grades, from slight to severed, scattered throughout the region (Santana and Díaz, 2009).

- **Atmospheric Resource**

The Bajo Cauca region is located in the tropical forest zone (bh-T). Average rainfall in the su-bregion ranges between 2,400 and 4.000 mm, with rain periods between April and November and a dry period between December and March.

The municipality of Nechí shows the highest rainfall in the su-bregion, almost doubling the rainfall in Cauca.

Table 2-2 Heights, temperatures and average rainfall for the Bajo Cauca municipalities

Municipality	Altitude (masl)	Temperature (°C)	Annual rainfall (mm)	Extension km ²			
				Total	Thermal floor layers		
					Warm	Medium	Cold
Cáceres	100	28.0	2,771	1,973	1,873	100	0
Caucasia	51	27.3	2,576	1,441	1,441	0	0
El Bagre	50	26.8	3,471	1,563	1,563	0	0
Nechí	20	26.7	4,969	914	914	0	0
Tarazá	50	27.0	3,133	1,560	1,480	74	0
Zaragoza	50	27.0	4,150	1,064	1,060	0	0

Source: Perfil regional del Bajo Cauca Antioqueño, Gobernación de Antioquia. Adapted by INERCO Consultoría Colombia, 2016.

- **Strategic ecosystems and environmental protection areas**

The sub-region has different strategic ecosystems and protected areas, including the regional protection area called *Reserva Natural Bajo Cauca - Nechí*, forest reserve under Law 1 of 1959 of the Magdalena region and the Paramillos Natural National Park.

Reserva Natural Bajo Cauca-Nechí

Located to the northeast of the department, in jurisdiction of the Cáceres, Zaragoza and Anorí municipalities, with an approximate area of 45,569 ha. Based on the Holdridge classification system, the reserve corresponds to the tropical and wet tropical forest. There are extensive masses of forest still not intervened that accommodate a large amount of fauna. It is located in the northern foothills of the central Mountain Range, with predominance of mountainous relief, crossed by deep canyons, ranging from 100 m.a.s.l. to 1000 m.a.s.l.

There is predominance of moderate to low hill relieve in the reserve, with average altitude of 400m on average. The reserve soils have low to very low fertility, with low PH, high presence of aluminum, low phosphorous availability and total bases, and medium organic carbon. These characteristics do not allow for establishing agricultural and livestock farming activities, as their productivity will decline rapidly, resulting in degraded, totally non-productive soils. The most outstanding features of flora in the reserve is its richness, high diversity and high endemism. There is a high number of individuals belonging to vegetation species considered endangered or which are endemic in the region. The reserve forests are considered important genetic banks, with great potential for production of food, medicines, gums and timber. It is also worth mentioning that the reserve received every year a significant number of migratory birds from North, Central and South America, looking for weather conditions to reproduce and feed (Gobernación de Antioquia, 1999 moved to the

zone to engage in mining activities). There are population moved to the area to engage in mining activities due to the gold producing richness of the basins and subsurface.

Magdalena forest Reserve Area, Law 2 of 1959

In this jurisdiction, there is the forest reserve of the Magdalena River, which includes part of the territory under jurisdiction of Corantioquia, over an area of 352.483 ha. Located in the territory of Panzenú and Zenufan), in the municipalities of El Bagre, Nechí, Remedios, Segovia and Yondó, respectively (Corantioquia, 2006).

Paramillo National Natural Park

It is located in the north end of the Western Mountain Range, covering the north part of the department of Antioquia and the south of the department of Córdoba. It extends over 460,000 ha. Paramillo is the final extension of the western Mountain Range, with great biological diversity and great cultural richness. This area lodges communities of the Emberá ethnia, whose cultural traditions, in spite of great pressure, belong over time. Given the characteristics and location of the park within a productive region, there are farmers who have settled in some areas of the park. It is a source of water supply, supplying water and Energy to a large area of a country's northwestern area (Corantioquia, 2006).

2.3 Socio-economic Characterization

This section will show the main indicators of the socio-economic indicators for the municipalities of Nechí, Tarazá, Caucasia, El Bagre, Cáceres and Zaragoza, having consulted official secondary information sources.

- **Demographic processes**

Population composition

According to population projections of DANE, the population of Antioquia in 2015 was 6,456,299 inhabitants by 30th June, out of which 78.22% were located in the municipal capitals. As regards the Bajo Cauca region, accounts for 272,951; 61.37% of which were located in the municipal capital and only 38.63% lived in the rural area (DANE, 2011).

The same trend is observed in almost every municipality in the sub-region, except for Cáceres and Zaragoza, where the rural population adds up to 77% and 54.53% of the total population, respectively. It is worth to highlight the high concentration of people in the urban area of Caucasia (82.18%).

Below, it is presented the population distribution of urban and rural municipalities in Bajo Cauca region:

Table 2-3 Population composition by municipal capital. Bajo Cauca, Antioquia

Municipalities and sub-regions	2015 Population			People in municipal capital (%)	People in the rest of the area (%)
	Total	Municipal capital	Other		
Total Dept.	6,456,299	5,050,047	1,406,252	78.22	21.78
Bajo Cauca	272,951	167,514	105,462	61.37	38.63
Cáceres	37,806	8,695	29,111	23.00	77.00
Caucasia	112,168	92,180	19,988	82.18	17.82
El Bagre	49,583	25,955	23,628	52.35	47.65
Nechí	14,510	12,728	27,238	87.72	187.72
Taraza	42,641	26,693	15,948	62.60	37.40
Zaragoza	30,738	13,978	16,760	45.47	54.53

Source: DANE: Demografía y población – Proyección de población 2015, 2011. Adapted by INERCO Consultoría Colombia, 2016.

According to DANE's population projections for 2015, the most populated municipalities were Caucasia (112,168), El Bagre (49,583) and Tarazá (42,641), while the least populated was Nechí (14,510) (DANE, 2011).

Ethnic Groups

Over the years, different ethnic groups have arrived into the Bajo Cauca: afro-descendants and indigenous people. In this regard, according to the DANE's population projection data for 2015, there was 4,099 indigenous people who represent 14.18% of the total in the department, with Zaragoza being the most populated municipality, accounting for 1,673 indigenous people. In the sub-region, there are 42,443 afro-descendants, corresponding to 7.16% of total in Antioquia (DNP, 2016).

Table 2-4. Ethnic Groups. Bajo Cauca, Antioquia

Sub-regions and municipalities		Total Dept.	Sub-regional	Cáceres	Caucasia	El Bagre	Nechí	Taraza	Zaragoza
Total		6,456,299	272,951	37,806	112,168	49,583	14,510	42,641	30,738
Ethnic Group	Indigenous	28,914	4,099	588	945	763	50	80	1,673
	ROM	75	0	0	0	0	0	0	0
	Raizal	552	35	6	3	1	2	9	14
	Palenquero	0	0	0	0	0	0	0	0
	Afro-Colombian	593,174	42,443	7,643	8,442	7,795	6,323	2,664	9,576
None		5,833,584	226,374	29,569	102,778	41,024	8,135	39,888	19,475

Source: DANE: Demografía y población – Censo, 2005. Adapted by INERCO Consultoría Colombia, 2016.

- **Education**

Illiteracy

The illiteracy rate in the Bajo Cauca sub-region is higher than average in the department. The municipalities with the most critical situation are Cáceres and Tarazá, accounting for 20.95% and 20.50% of illiterate population, respectively. The municipality with the lowest illiteracy rate is Caucasia, with 12.42%.

Table 2-5 . Illiteracy rate

Municipalities	Total (%)	Urban (%)	Rural (%)
Antioquia	7.06	4.86	15.24
Bajo Cauca	16.31	12.67	22.95
Cáceres	20.95	17.65	21.95
Caucasia	12.42	10.53	21.83
El Bagre	15.22	12.17	21.81
Nechí	18.37	15.01	23.45
Tarazá	20.50	17.78	24.49
Zaragoza	19.42	13.74	25.34

Source: DANE: Demografía y población – Censo, 2005. Adapted by INERCO Consultoría Colombia, 2016.

It is important to note that the presented data can be obtained at the Municipal profiles made by the DANE (Census 2005). These data are considered in the analysis of the population age greater than or equal to five (5) year old.

- **Armed Conflict**

In the Bajo Cauca region several fronts of the FARC operate, as well as remains of the ELN and Criminal Gangs, successors of paramilitary armies. This phenomenon is derived from the strategic position of the region for performance of illegal activities, as it is part of a

mobilization corridor going from Catatumbo to the Urabá antioqueño, crossing the South of Cesar, south of Bolívar, Middle Magdalena, Northeast and Bajo Cauca Antioqueño; moreover, it is an important source of income by gold exploitation throughout the region.

It has been determined that the armed conflict in the sub-region has been caused by two factors as a cause or complement. The first is the existence of illicit crops in the municipalities of Bajo Cauca. The second refers to areas of high gold production in the municipalities of Cáceres, Caucasia, El Bagre, Nechí, Tarazá and Zaragoza (Unidad para la atención y reparación integral de víctimas, 2014).

The civil population has been the victim of various violent actions such as homicides, extortions, displacement threats and recruiting of minors in the armed conflict. Violence indicators have decreased in recent years because of agreements entered into with the various armed groups.

Historical data are found up to 2015, showing that for the end of this year 4,384 cases for the Bajo Cauca region were registered, which represent 23.07% of the departmental total (Registro Único de Víctimas, 2016).

Table 2-6 . Displacement data in Bajo Cauca Region

Municipales	2011	2012	2013	2014	2015
Antioquia	57,029	48,394	45,165	31,033	19,006
Sub-region	9,580	5,921	11,587	6,499	4,384
Cáceres	2,413	1,388	980	1,161	540
Caucasia	2,495	967	1,155	1,072	699
El Bagre	857	1,019	5,474	1,899	754
Nechí	640	455	471	433	353
Tarazá	1,690	1,216	2,640	1,275	729
Zaragoza	1,485	876	867	659	1,309

Source: Registro Único de Víctimas, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- **Economy**

The base of economy in the sub-region is the exploitation of gold and silver, livestock farming and agriculture, including crops such as maize, yucca, rice and plantain. The rubber-cacao system has become a significant alternative to substitute illegal crops and a source for development of the sub-region. As regards use of land, coverage of pastures devoted to extensive livestock farming is predominant.

In order to determine the economic importance of each municipality within the department, the relative weight corresponding to the distribution of the value added to the department (contribution of each municipality to departmental GDP) established from sectoral indicators. The GDP of department of Antioquia was COP \$ 101,989,000,000,000 for 2014 (DANE, 2015).

Down below, data for the municipalities in the region are presented:

Table 2-7. Relative weight of municipalities of Bajo Cauca in GDP of the department of Antioquia

Municipalities	Value added (Billions of pesos)	Municipal relative weight in Departmental GDP (%)
Cáceres	283	0.3
Caucasia	963	1.1
El Bagre	558	0.7
Nechí	193	0.2
Tarazá	296	0.3
Zaragoza	237	0.3

Source: DANE – Cuentas Nacionales: PIB por Departamento, 2014. Adapted by INERCO Consultoría Colombia, 2016.

The analyzed municipalities in total provide maximum 3% of departmental GDP. In this regards, it is possible to identify that Caucasia is the municipality with greater participation in the distribution of departmental GDP and the lowest contribution is Nechí.

- **Unsatisfied basic needs**

The index of unsatisfied basic needs determines the level of basic needs that have not been met. This analysis is based on criteria of appropriate housing, availability of basic utilities, domestic space quality, level of school attendance and economic dependency degree (DANE, 2008).

Colombia reports 27.78% of the population in Unsatisfied Basic Needs conditions, and Antioquia 22.96%. However, it is evident that in the municipalities of this region the satisfaction basic needs levels are lower than national and departmental data, among which stand out Caucasia (52.1%) and El Bagre (50.75%) for being the best performers.

Table 2-8 . Unsatisfied Basic Needs Index in Colombia and Antioquia

Municipalities	Unsatisfied Basic Needs		
	Total (%)	Municipal capital (%)	Other (%)
Colombia	27.78	19.66	53.51
Antioquia	22.96	15.90	47.48

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

Data indicate that the municipality that has the lowest rate of UBN is El Bagre, and the highest rate of UBN is reported by the municipality of Nechí.

Table 2-9 . Unsatisfied Basic Needs Index in Bajo Cauca region

Municipalities	People UBN		
	Total (%)	Municipal capital (%)	Other (%)
Cáceres	66.81	61.25	68.48
Caucasia	52.41	48.55	70.84
El Bagre	50.75	40.41	71.33
Nechí	68.13	62.40	76.67
Taraza	61.97	62.02	61.90
Zaragoza	64.30	45.74	82.69

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

With relation to the availability and access to utilities, specifically water, it should be noted that Antioquia has coverage of 85.7%. Aqueduct coverage reported by the different municipalities of this region is below the departmental coverage. The municipality of Cauca has the highest coverage (82.4%) and the municipality of Nechi, the lowest (42.7%) (DNP, 2016).

Table 2-10 . Aqueduct coverage in Bajo Cauca sub-region

Municipalities	Coverage (%)
Cáceres	47.6
Caucasia	82.4
El Bagre	73.8
Nechí	42.7
Taraza	66.8
Zaragoza	54.7

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.
Adapted by INERCO Consultoría Colombia, 2016.

The water quality information is available for consultation in the Index of Water Quality Risk- IWQR, which responds to the following risk classification:

Table 2-11. Index Ranges of Water Quality Risk

Compliance levels	Ranges
Inviabile sanitariamente	>70 y ≤ 100
Alto	>35 y ≤ 70
Medio	>14 y ≤ 35
Bajo	>5 y ≤ 14
Sin Riesgo*	>0 y ≤ 5

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal. Adapted by INERCO Consultoría Colombia, 2016.

The water quality information from the municipalities of El Bagre and Zaragoza is not available in the Single Information System - SIS (Sistema Único de Información de Servicios Públicos, 2016). For other municipalities, it is presented below Risk Index of Water Quality - RIWQ:

Table 2-12 . RIWQ Bajo Cauca sub-region 2009 – 2011

Municipalities	2009	2010	2011
Cáceres	0.13	0.98	0.97
Caucasia	0.59	0.27	0.15
Nechí	0.27	1.11	1.3
Tarazá	0.61	0.09	0.24

Source: SUI – IRCA por Prestador de Servicios, 2012. Adapted by INERCO Consultoría Colombia, 2016.

Data reported by the municipalities of Cáceres, Caucasia, Nechí and Tarazá for the period 2009-2011, show that the water quality presents no risk (Sistema Único de Información de Servicios Públicos, 2016).

- **Institutionalization**

This section provides information related to different entities performance and institutions transparency in the municipalities of Cáceres, Caucasia, El Bagre, Nechí, Tarazá and Zaragoza. For this, the Municipal Integral Performance Index developed was consulted by NPD.

- Integral Municipal Performance

Studies of municipal integral performance assess public management of municipalities, public policy making decisions and resource allocation under four main criteria:

Table 2-13 . Components of integral municipal performance index

Components	Content
Efficacy	<ul style="list-style-type: none"> - Advancement percentage of the Development Plan. - Achieving goals percentage in products.
Efficiency	<ul style="list-style-type: none"> - Results obtained from required inputs on Health, Drinkable water, and Education.
Legal requirements	<ul style="list-style-type: none"> - Compliance of Law 715 of 2001 and Law 1176 of 2007 in relation to the Participation General System.
Administrative management	<ul style="list-style-type: none"> - Administrative capacity, understood as the availability of human, technological resources, actions adoption, methods, procedures and mechanisms for the prevention, control and evaluation for continuous improvement of territorial entities management. - Fiscal performance.

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal, 2014. Adapted by INERCO Consultoría Colombia, 2016.

Qualification ranges of Municipal Integral Performance are presented in Table 2-14, considering that the "Critical" level, include those municipalities that do not have information or are not assessable because of inconsistencies in data provided to NPD:

Table 2-14 . Compliance ranges Integral Municipal Performance

Compliance levels	Ranges
Outstanding	≥80
Satisfactory	≥70 y <80
Medium	≥60 y <70
Low	≥40 y <60
Critical	<40

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal, 2014. Adapted by INERCO Consultoría Colombia, 2016.

The information reported by the NPD evidences that Antioquia is qualified with an average performance (64.3%). Below, the information for Bajo Cauca region is presented:

Table 2-15 . Integral Performance Indicator 2013 for municipalities of Bajo Cauca Region

Municipalities	Efficacy 2013	Efficiency 2013	Legal requirements compliance 2013	Fiscal Management 2013*	Integral performance Indicator 2013	Classification ranges
Cáceres	89.51	47.12	49.47	74.11	65.10	Medium
Caucasia	57.49	67.05	88.39	86.55	74.90	Satisfactory
El Bagre	33.16	65.24	66.47	79.29	61.10	Medium
Nechi	18.39	35.00	52.20	74.43	45.00	Low
Taraza	0.00	52.72	44.65	66.09	40.80	Low
Zaragoza	100.00	51.88	91.83	62.50	76.60	Satisfactory

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal. Adapted by INERCO Consultoría Colombia, 2016.

3 NORTHEAST AND MUNICIPALITY OF BURITICÁ

3.1 General aspects

The Northeastern region in Antioquia is located over the Eastern side of the central Mountain Range and the San Lucas hill. The northeast region of Antioquia comprises the municipalities of Remedios and Segovia, and is rich in mining and timber production. It's populating process by settlers originated late in the XVI century as a result of the country's conflict or in search for mining wealth.

Later on, with the presence of Frontino Gold Mines, a US Company that arrived in Remedios in 1869, some settlers arrived from the Bajo Cauca, Chocó, Córdoba, Sucre, Santander and Bolívar regions. Thus, this gave rise to a wage-earning mining artisanal exploitation and owners of small “*entables*” (sites where gold is extracted).

The Northeastern territory has an extension of 8,544 km² (13.6% of the department's area), being second in the department's sub-regions. The municipality with the largest extension is Remedios with 1,985 km² and the smallest one is Cisneros with only 46 km².

With respect to the municipality of Buriticá, it is located on the right flank of the western Mountain Range, on the left bank of the Cauca River. It limits to the North with Peque, to the South with Santa Fe de Antioquia and Giraldo, to the east with Sabanalarga and to the west with Cañas Gordas. Buriticá's extension is 364 km², with heights ranging between 1,625 and 2,000 m.a.s.l.

3.2 Environmental Characterization

- **Water resources**

The main rivers crossing the sub-region are Porce, Nechí, Mata, Volcán, La Cruz, Nus and Naré (Antioquia Governor's Office, 2002).

In the municipality of Buriticá, the main tributaries of the Cauca River are the streams of La Cuatro, La Clara, Tesorera and Aguada. The main watershed of the municipality is that of the Cauca River, with an extension of 15,810 km² in the department of Antioquia.

- **Aquifers and basins supplying water to aqueducts**

In the Antioquia Northeastern region, water intake takes place in micro-basins close to the municipalities, except for Yolombó, with water intake in the El Sereno dam. The flow rate authorized in the sub-region amounts to 304 L/seg.

Aqueduct coverage in the area is good except in Segovia, where it amounts to 65% and Cisneros, with 86%. In this zone, 60% of the municipalities treat their water for human consumption and all municipalities have a Sanitation and Discharge Management Plan in place.

The basins in the municipality of Buriticá are Los Cuatros, La Clara, Tesorera and Aguanda. However, in spite of having a numerous group of water bodies in the territory, the availability of water for human use is limited because of the high degree of degradation (EOT, 1999). Water intake takes place in the Miraflores, Macías and La Trigueña, the quality of which is fair as there is contamination with coliforms.

- **Relief and soils**

The relief in northeastern Antioquia is formed mainly by mountains in lines and beams, with valleys and colluvials. The relief ranges from moderately sloped to strongly scarped, with slopes fluctuating between 50% and 75%.

Soils have medium and fine textures, well drained, slightly deep, and limited in some parts by rocks and gravel; they undergo erosion caused by diffuse runoff, terraces, hoof marks, mass movements and minor land sliding. The degree of erosion may be moderate in some areas. During dry seasons, there may be cracks of little amplitude and depth (Idea, 2010).

The physiography of the territory of the Buriticá municipality has accidents where slopes of over 50% are predominant, with small valleys that are less sloped.

- **Atmospheric resource**

The average temperature in Northeastern Antioquia is approximately 21.6 Celsius. The next figure depicts monthly behavior of ambient temperature in Cisneros. The zone is located on the temperate thermal floor, with heights ranging between 1,000 to 2,000 m.a.s.l., with temperatures ranging between 20.2°C and 24.3°C. It presents temperature decrease in September and October (Idea, 2010). Average relative humidity is 84%.

For Buriticá, four life zones are identified, according to Holdrige classification, with the following characteristics:

Table 3-1. Characteristics by life zone in the municipality of Buriticá

Life zone	Biotope temperature	Rainfall (mm/year)	Altitude (masl)
Bs-T	24°C	1,000-2,000	400-1,000
Bh-PM	18°C-24°C	1,000-2,000	1,000-2,000
Bh-MB	12°C-18°C	1,000-2,000	2,000-2,900
Bmh-M	6°C-12°C	1,000-2,000	Over 2,900

Source: EOT, 1999. Adapted by INERCO Consultoría Colombia, 2016.

- **Strategic ecosystems and environmental protection areas**

Based on the overlaying of sub-region maps in Northeastern Antioquia and Buriticá, Forest Reserves framed by Law 2 of the Magdalena and Pacific regions were found, added to the Regional Protection Forest Reserve of San Lorenzo.

Magdalena River Forest Reserve

This forest reserve zone was created by Law 2 of 1959 and supplemented by Decree 0111 of 1959 to cover a total area of 5,823,468 Ha. The reserve has been intervened by various settlement processes; therefore, 63% of its initial area was subtracted and currently the reserve extends over an area of 2,155,591 Ha. For purposes of the ENV/Mining plan, this reserve covers portions of the municipalities of Segovia and Remedios towards the East.

Regional Protection Forest Reserve of San Lorenzo

Through Agreement 263 of November 22th, 2011, the Regional Protection Forest Reserve of San Lorenzo was delimited and declared, with an extension of 4,959.88 Has, which comprises the municipalities of Alejandría, San Rafael, Santo Domingo and San Roque. Within the municipality of San Roque, for purposes of the ENV/Mining program, the rural districts of El Porvenir, La Ceiba, Nucito and Playa Rica are included.

3.3 Socio-economic characterization

This section will show the main indicators of the socioeconomic component for the municipalities of Remedios, San Roque, Segovia and Buriticá, to which end official secondary sources of information have been consulted.

- **Demographic processes**

Population make-up

According to data provided by DANE, the population projected for 2015 in Antioquia amounted to 6,456,299 by June 30th. With respect to the municipalities that are the subject of this characterization, details are included in Table 3-2.

Table 3-2 Population composition, by municipal capitals – 2015

Municipalities and sub-regions	2015 Population			People in municipal capital (%)	People in the rest of the area (%)
Name	Total	Municipal capital	Other		
Total Dept.	6,456,299	5,050,047	1,406,252	78.22	21.78
Sub-regional	92,763	50,440	42,323	54.38	45.62
Buriticá	6,601	1,551	5,050	23.50	76.50
Remedios	29,199	10,657	18,542	36.50	63.50
San Roque	16,789	6,298	10,491	37.51	62.49
Segovia	40,174	31,934	8,240	79.49	20.51

Source: DANE: Demografía y población – Proyección de población 2015, 2011. Adapted by INERCO Consultoría Colombia, 2016.

As can be observed, Segovia is the main urban center of the Northeastern region, and it is classified as a secondary relief center, which has mostly administrative, commercial, banking, health and education functions. In Buriticá, Remedios and San Roque, the distribution of the population is bigger in the rural area.

Ethnic Groups

The region is mostly mestiza, as in the rest of the department. There are a significant number of afro-descendant populations in Remedios and Segovia.

Below, ethnic population distribution of municipalities of Remedios, San Roque, Segovia and Buriticá is presented:

Table 3-3. Ethnic groups

Sub-regions and municipalities		Total dept.	Sub-regional	Buriticá	Remedios	San Roque	Segovia
Total		6,456,299	92,763	6,601	29,199	16,789	40,174
ETHNIC GROUP	Indigenous	28,914	454	0	46	2	406
	ROM	75	0	0	0	0	0
	Raizal	552	8	0	1	1	6
	Palenquero	0	0	0	0	0	0
	Afro-Colombian	593,174	11,190	100	4407	17	6,666
None		5,833,584	81,111	6,501	24,745	16,769	33,096

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.
Adapted by INERCO Consultoría Colombia, 2016.

- **Education**

Illiteracy

Illiteracy rates are greater than those given as average for the department among populations reviewed. In addition, the illiterate population in all rural areas is higher than in urban capitals. The lowest literacy rate was found in San Roque.

Below, illiteracy level for municipalities of Remedios, San Roque, Segovia and Buriticá are presented:

Table 3-4. Illiteracy rate

Municipalities	Total (%)	Urban (%)	Rural (%)
Antioquia	7.06	4.86	15.24
Sub-region	14.42	10.95	18.71
Buriticá	23.75	8.83	27.02
Remedios	16.79	12.89	19.38
San Roque	10.55	6.20	12.63
Segovia	13.25	11.47	21.79

Source: DANE: Demografía y población – Censo, 2005. Adapted by INERCO Consultoría Colombia, 2016.

- **Armed Conflict**

The armed conflict has been presented in various forms, of which the most common are armed confrontations, which can be related to the territorial control by armed groups, and

the existence of areas of high gold production in the municipalities of Remedios, San Roque and Segovia (Unidad para la atención y reparación integral de víctimas, 2014).

The territory is occupied by several illegal armed groups, who take advantage from development of their expansion projects of their presence in this area, thus control strategic corridors that allow for their moving and maintaining financing sources, both legal and illegal. There is presence of FARC-EP, through fronts 36 and 4°; the ELN acts through the Capitán Mauricio Company; moreover, there are post-demobilization armed groups from the AUC (Rastrojos, Urabeños, Paisas, Águilas Negras); and the Army, which carries out important military operations.

It is evident that 795 cases for the region were registered, approximately 4.18% of the cases reported at departmental level recorded by the end of 2015. Most are developed in Segovia and the municipality less affected is Buriticá (Registro Único de Víctimas, 2016).

Table 3-5. Displacement data in Buriticá region and Northeast Antioquia

Municipalities	2011	2012	2013	2014	2015
Antioquia	57,029	48,394	45,165	31,033	19,006
Sub-region	813	4,137	2,388	1,129	795
Buriticá	29	58	132	75	29
Remedios	226	1,343	690	269	219
San Roque	87	91	122	65	44
Segovia	471	2,645	1,444	720	503

Source: Registro Único de Víctimas, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- Economy**

The main economic activity is gold mining. After the Bajo Cauca, the region is positioned as the second gold producing region in Antioquia. As regards agriculture, its main product is sugar cane, followed by coffee, maize, beans and plantain. As to cattle farming, meat and milk are the main products it markets. In a lower scale, there are fishing activities, timber exploitation and trading. The low agro-pastoral production is caused by the presence of farmers who only engage in subsistence crops: yucca, plantain, coffee and, to a lesser extent, maize and cacao.

In order to determine the economic importance of each municipality within the department, it is presented the relative weight corresponding to the distribution of the departmental value added established from sectoral indicators. The departmental GDP of Antioquia is \$ 101,989,000,000,000 for 2014 (DANE, 2015).

Below, data for the municipalities in the region are presented:

Table 3-6. Relative weight of municipalities of Buriticá and Northeast sub-region in the department of Antioquia GDP

Municipalities	Value added (Billions of pesos)	Municipal relative weight in the departmental GDP (%)
Buriticá	69	0.1
Remedios	249	0.3
San Roque	135	0.2
Segovia	466	0.5

Source: DANE – Cuentas Nacionales: PIB por Departamento 2014 por Ambiental. Adapted by INERCO Consultoría Colombia, 2016.

The analyzed municipalities provide 1.1% of the departmental GDP. On the same issue, it is possible to identify that Segovia is the municipality with the highest participation in the Departmental GDP distribution, and the lowest is Buriticá.

- **Unsatisfied basic needs**

The municipalities of this region show the lowest unsatisfied basic needs levels compare with national and departmental data, in which outstands Buriticá (70.30%), the lowest performance among the analyzed municipalities. Moreover, it is evident that other municipalities indicate unsatisfied basic needs conditions in greater portions, up to 50%. The highest rate, it is reported in San Roque, as it is showed in the following table:

Table 3-7. Unsatisfied basic needs in Buriticá region and Northeast of Antioquia

Municipalities	People UBN		
	Total (%)	Municipal capital (%)	Other (%)
Buriticá	70.30	27.58	78.54
Remedios	47.56	36.99	54.51
San Roque	38.12	27.61	43.25
Segovia	41.37	35.52	66.54

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

Aqueduct coverage reported by the different municipalities of this analysis is below to the coverage department. The municipality Remedios has the highest coverage percentage (68.4%) and the lowest coverage is Buriticá (38.1%), (DNP, 2016).

Table 3-8. Aqueduct coverage in Buriticá and Northeast of Antioquia Sub-region

Municipalities	Coverage (%)
Buriticá	38.1
Remedios	68.4
San Roque	66.4
Segovia	63.1

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.

Adapted by INERCO Consultoría Colombia, 2016.

Risk Index of Water Quality - RIWQ was reported only by the municipality of Segovia for the period 2009-2011, showing that water quality presents no risk (Sistema Único de Información de Servicios Públicos, 2016).

Table 3-9. IRCA Buriticá and Northeast sub-region of Antioquia 2009 – 2011

Municipalities	2009	2010	2011
Segovia	2	1.77	0.51

Source: SUI – IRCA Prestador de Servicio, 2012. Adapted by INERCO Consultoría Colombia, 2016.

- **Mercury contamination**

According to the study carried out by Paul Cordy (2013), the department of Antioquia generates 46% of the gold produced small and artisanal scale, and annually emits 93.4 tons of mercury to the environment. The municipality of Segovia emits 22.4 tons of mercury to the environment, of which 8.4 tons are released in the form of steam during the process of burning and smelting amalgam of gold and mercury, because these processes are done without adequate condensation systems in the urban center of Segovia.

In the following figure, the average concentrations of mercury in the streets of Segovia is shown. It is important to keep in mind that the maximum concentration allowed by the World Health Organization is 1,000 ng/m³, o 1 µg / m³.

Figure 3-1 Average concentrations of mercury in the streets of Segovia

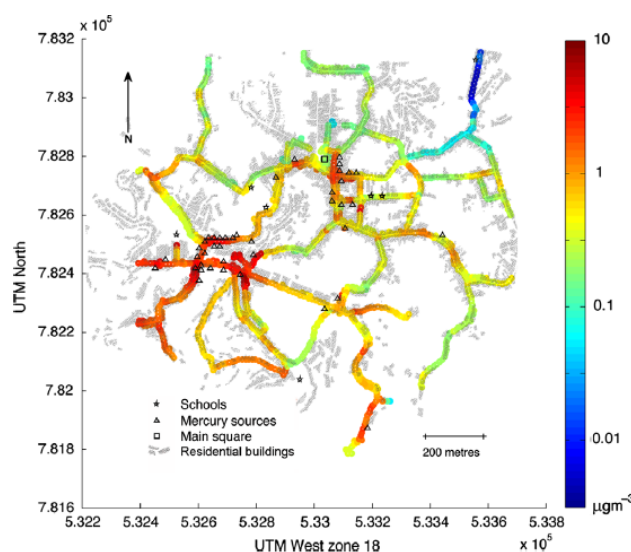


Fig. 4. Average mercury concentrations in the streets of Segovia. The World Health Organization hazard limit is 1000 ng m⁻³ (World Health Organization, 2000).

Source: Cordy et al., 2013.

- **Institutionalization**

In this section, it is provided information related to the performance and transparency of institutions in Buriticá and municipalities in the Northeast sub-region of Antioquia 2009. For this, the Integral Municipal Performance Index developed by DNP was consulted.

- Integral municipal performance

Below, the information Buriticá and the Northeast sub-region of Antioquia is presented.

Table 3-10. Integral performance indicator 2013 for Buriticá and the Northeast region of Antioquia

Municipalities	Efficacy 2013	Efficiency 2013	Legal requirements compliance 2013	Fiscal Management 2013*	Integral performance Indicator 2013	Classification Range
Buriticá	59.26	73.47	64.73	67.86	66.4	Medium
Remedios	27.40	33.73	65.91	76.49	50.9	Low
San Roque	51.29	73.23	71.82	77.16	68.4	Medium
Segovia	23.45	30.39	44.43	62.25	40.1	Low

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal, 2014. Adapted by INERCO Consultoría Colombia, 2016.

4 UPPER AND MIDDLE ATRATO

4.1 General aspects

The Medio Atrato region is located to the north of Quibdó and it is crossed by the Atrato River from South to North, limited by the municipalities of Alto Baudó, Bojayá and Quibdó (Chocó), and the municipalities of Vigía del Fuerte and Urrao (Antioquia). Its extension is 562 km², and it has 10 small villages, 23 rural districts and 7 indigenous communities, which include Baudogrande, Puné, Puerto Salazar, San Francisco de Tauchigadó, Boca de Agua Clara and Boca de Bebará, among others. It is rich because of its exuberant tropical forest with its diverse flora and fauna, as well a water sources, surrounded by a series of marshes.

The Alto Atrato region is made up of the municipalities of Atrato, Cértegui, El Cantón de San Pablo, Río Quito and Quibdó located in the foothills of the Western Mountain Range, in the Eastern side of the Department of Chocó. It extends over 5,190.5 km²

4.2 Environmental Characterization

- **Water resources**

The water network of the Middle Atrato region is located between the watersheds of the Beté, Amé, Buey, Tanguí, Bebará, Bebaramá, Agua Clara, Paina and Puné rivers. Joining the hydrological system in the municipality of Medio Atrato there are approximately 47 marshes, out of which only 30 are shown in maps and the community reported nearly 27.

The main fluvial body in the municipal water Network is the watershed of the Atrato River located in the northwestern part of Colombia in the departments of Chocó (over 60% of all its area). The Atrato River, being in one of the rainiest seasons in the world, is considered one of the basins with highest yield. The watershed of the Atrato River captures on average 1,298 m³/sec (EOT. 2005-2016).

In the Alto Atrato area, there are high value tributaries such as Grande River, Habita, Aguilón, El Barbudo, Atratico, El Piñón, El Toro, Girardot, and La Playa.

- **Aquifers and basins that supply water to aqueducts**

The microbasins supplying water to aqueducts within the municipal territory are the streams of El Chorro, La Virgen and Ángel Antonio.

In 90% of cases, homes use water from the rivers, streams or springs, most of them contaminated by different untreated solid and liquid discharges. Only a few homes benefit from rainwater collected in small drums or tanks, without any protection before consuming it.

It is also important to consider the Cabi river watershed, because it is the only supply source of water for Quibdó. Coupe river basin is located in the between the municipalities of Quibdó and Atrato, with an area of 16,219 ha. The ecosystem, which is classified as tropical rainforest, is considered one of the wettest areas and the most biodiverse of the world because of its high rainfall conditions (8,000 mm/year), temperature (26.4 °C annual average) and relative high average humidity (86%). It has been possible to identify that the river is affected by alluvial mining activities, deforestation in the upper-middle part and improper disposal waste in urban areas (Sanabria Botero & Diaz Cañadas, 2008).

- **Relief and soils**

In the alluvial plains of the Atrato region, there are two different areas. The first one that overflows periodically and in general maintains shallow water table levels and, the second one of decantation, which is the lowest part of the basin and is thus waterlogged most of the year; it shows clayey soils being formed, without pore space occupied by water, that is, with 100% saturation. In the flood plains, it is common to find marshes that make up the sediment receiving and deposition areas during the heavy rains season, when waters overflow dikes or break and generate debris spills (OSSO, 1998).

Soils in the alluvial plain are unstable, with low cohesion and depth and correspond to de-evolution stage observed in whom arose mounds where bushes grow. The landscape shape in the alluvial plain of the Atrato River depends on the level, frequency and duration of floods, which can be either permanent or periodical (Alcaldía de Riosucio, 2001).

A characteristic of rock decay's in the basin of the Atrato river is that most of the material become clayey ores, with high predominance of Kaolinities (made up of hydrated aluminum and silica), which generate greyish tone soils. A high percentage of soils are of this type, particularly those located on the eastern flank of Western Mountain Range and the Serranía del Baudó (Malagón, et al, 1995).

The materials that form the alluvial plains of the Atrato River are mostly alluvial sediments, sands, silts and clays (Alcaldía de Riosucio, 2001), generated during the denudating process of the Western Mountain Range and the Serranías del Baudó and Darién, which were formed in the late Tertiary and through the Quaternary, accompanied by tectonic and coast

uplifting processes (IGAC, 2002). Sedimentary materials are found on the joining of the main dignitaries. Soils are shallow and poorly drained, with low fertility (Codechocó, 2006).

- **Atmospheric resources**

For purposes of this description, the Holdrige life zones classification was used.

Table 4-I Holdrige Life Zones Classification

Sub-region	Life zone	Temperature (°C)	Rainfall (mm)
Middle Atrato	bmh-T	24	4,000-8,000
	bp-T	24	Superior a 8,000
Upper Atrato	bh – MB	12	2,000-4,000
	bh- PM	18-24	2,000-4,000
	bmh – PM	18-24	4,000-8,000
	bmh – T	24	4,000-8,000

Source: INERCO Consultoría Colombia, 2014.

- **Strategic ecosystems and environmental protection areas**

In the sub-region, there are several environmental protection areas such as the Pacific Forest Reserve (Law 2 of 1959), the Complex of Heights of Citara, the Regional Forest Protection Reserve of Farallones del Citara, the Utría National Natural Park, the Aguita-Mistrato regional protection area of the Integrated Management District of the Cuchilla Cerro Plateado. The environmental protection areas overlapping with the municipalities of interest in the ENV/Mining program are the Law 2 Pacific Forest Reserve and the Citara Highlands Complex.

The sub-region has the following ecosystems of Environmental interest and Environmental protection areas:

- **Marshes (Wetlands)**

In the watershed area of Atrato, 65,000 ha of the flooded area are productive as regards fishing activity for more than half a year. Therefore, it is considered to be of environmental interest as supplier of animal protein, not only for people in the municipality but also for people in the city of Quibdó and other Colombian regions (EOT. 2005-2016).

These marshes, as well as the creeks, play a significant role for the control of high flow level growth and flooding in the Atrato river and its tributaries, as said water bodies help mitigate

such unusually high flow levels that usually occur in towns located on the banks of these rivers and in lands devoted to agriculture and livestock farming activities.

- **Natural Reserve Farallones del Citará**

It is situated in the Western mountain range, and the municipalities of Carmen de Atrato and Bagadó in the department of the Choco, and the municipalities of the Andes, Ciudad Bolívar and Betania in the department of Antioquia. Its borders have not yet been defined for its management.

Vegetation studies realized towards the eastern slope principally collected 823 plants of which 73.9% have been determined to their species level, 16.8% were identified by their gender level; 6.5% are only classified by family and 2.8% were left completely undefined.

The area of Farallones del Citará preserves a high reserve of vertebrates and invertebrates, as well as a great heterogeneity in the habitat and seems to maintain a stable microclimate, which contributes to sustain a richness of species, but at the same time a great fragility, forbidding the area to support and excessive extraction of vegetable products, animals or minerals (Development Plan of the municipality of Bagadó, 2012).

4.3 Socio-economic Characterization

This section presents principal indicators of the social economic motive for the municipalities of Atrato, Cértigui, Cantón de San Pablo, Quibdó and Río Quito, for which the consultant team have consulted secondary official sources of information.

- **Demographic Processes**

Population Composition

According to the population projections data for 2015 provided by DANE, the population of Chocó was 500,093 inhabitants, out of which 49.18% were located in the municipal capitals. As regards the upper and middle Atrato, its population the same year will account for 152,637, 80.92% of which were located in the municipal capital and only 19.08% lived in the rural area.

While the population distribution in the department's capital is bigger in the municipal capitals, in the rest of the municipalities, the majority of the population is located in the rural area. The most populated municipality, according to DANE, is Quibdó (115,711), while the least populated is El Cantón de San Pablo (7,970).

Table 4-2. Population composition, by municipal capital

Municipalities and sub-regions	2015 Population			People in municipal capital (%)	People in the rest of the area (%)
Name	Total	Municipal capital	Other		
Total Dept.	500,093	245,923	254,170	49.18	50.82
Sub-regional	152,637	123,504	29,133	80.92	19.08
Atrato	9,927	3,498	6,429	35.24	64.76
El Cantón del San Pablo	7,970	3,486	4,484	43.74	56.26
Certeguí	10,068	6,293	3,775	62.51	37.49
Quibdó	115,711	107,643	8,068	93.03	6.97
Río Quito	8,961	2,584	6,377	28.84	71.16

Source: DANE: Demografía y Población-Proyecciones de población año 2015, 2011. Adapted by INERCO Consultoría Colombia, 2016.

Ethnic Groups

Over the years, different ethnic groups Choco have inhabited by afro-descendants and indigenous people. In this regard, according to the Census conducted by DANE in 2005, there are 43,991 indigenous people accounting for 5.35% of the total population in the department and 116,729 afro-descendants accounting for 42.02% of the total of Choco and 75.37% of the sub-regional population.

On the other hand, the indigenous people represent the 1.52% of the sub-region population accounting for 2,353 persons.

Table 4-3. Ethnic Groups

Sub-regions and municipalities		Total Dept.	Sub-regional	Quibdó	Atrato	Cantón San Pablo	Cértégui	Río Quito
Total		500,093	154,873	115,711	9,927	7,970	10,068	11,197
Ethnic group	Indigenous	43,991	2,353	1,504	15	72	201	561
	ROM	1	1	1	0	0	0	0
	Raizal	41	23	21	0	1	0	1
	Palenquero	0	0	0	0	0	0	0
	Afrocolombian	277,783	116,729	99,986	3,500	2,631	5,349	5,263
None		178,277	33,965	14,199	6,412	5,266	4,518	3,570

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.
Adapted by INERCO Consultoría Colombia, 2016.

- **Education**

Illiteracy

The illiteracy rate in the Upper and Middle Atrato sub-region is lower than the average in the department. The municipality with the most critical situation is El Cantón de San Pablo, accounting for 23.52% illiterate population. The location with the lowest illiteracy rate is Atrato at 9.80%.

Table 4-4. Illiteracy rate

Municipality	Total (%)	Municipal capital (%)	Other (%)
Chocó	17.61	10.42	27.17
Quibdó	15.20	12.60	47.20
Atrato	9.80	25.54	20.00
Cantón de San Pablo	23,52	21,63	24.87
Cértogui	9.87	2.76	18.80
Río Quito	21.97	19.58	43.29

Source: DANE: Demografía y Población – Censo, 2005. Adapted by INERCO Consultoría Colombia, 2016.

It is important to note that the data presented were obtained in the Municipal Profiles made by the DANE (Census 2005). These data considered the analysis of population of legal age or equal to five (5) years.

- **Armed Conflict**

The Atrato is the region of the Chocó with the highest violence indicators relative to the armed conflict. Illegally armed groups use this region as a corridor for mobility of, supplies, arms, and drugs from Antioquia, the Eje Cafetero and the Valle del Cauca up to the Pacific Ocean. It is also an area that capitalizes on resources from the production of mining and forestry, an area for illicit crops farming and related activities. Consequently, the community is a target for violence over who controls the region with massacres, trade and transportation blockings, displacements and extortions.

In the region of upper and middle Atrato, the presence of armed groups such as the columna móvil Libardo Garcia of Frente Arturo Ruiz FARC EP fronts 57, 30, 34 and Aurelio Rodriguez in the municipalities of Carmen de Atrato, Río Quito and Quibdó were reported. On another hand, the ELN operates with resistance fronts Cimarron, Manuel Hernández – El Boche and Ernesto Che Guevara in the upper part of Atrato River (Defensoría del Pueblo, 2014).

As evidenced, 1,549 cases were reported in the region by the end of 2015, accumulating 15.47% of total cases at departmental level. Most of these cases take place in Quibdó (Registro Único de Víctimas, 2016).

Below, the information of displacement event in the municipalities is presented:

Table 4-5. Displacement in upper and middle Atrato region

Municipalities	2011	2012	2013	2014	2015
Chocó	13,698	1,9621	18,717	16,678	10,011
Sub-region	2,809	2,840	3,321	3,232	1,549
Atrato	102	530	193	470	112
El Cantón de San Pablo	48	31	73	117	49
Certeguí	37	7	23	49	40
Quibdó	2,555	2,211	2,937	2,455	1,261
Río Quito	67	61	95	141	87

Source: Registro Único de Víctimas, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- **Economy**

Within the economy these municipalities excel in agriculture, mining, forest exploitation, exclusively dependent on the natural resources in an artisan way.

In some municipalities of the region, mining occupies first place in the economy, as well as being highly important in other municipalities analyzed. The entire region grows plantain, corn, sugar cane, and fruits (banana, lemon, avocado, borojó, chontaduro, pineapple, papaya) in an artisan form, and mostly for family use.

In order to determine the economic importance of each municipality within the department, it is presented the relative weight corresponding to the distribution of the value added to the department established from sectoral indicators. The GDP of the department of Chocó was \$ 2,914,000,000 in 2014 (DANE, 2015).

Table 4-6. Relative weight of municipalities of upper and middle Atrato sub-region in the Departmental GDP of Chocó

Municipalities	Value added (Billions of pesos)	Municipal Relative weight in the departmental GDP (%)
Quibdó	1.047	36.1
Atrato	44	1.5
El Cantón del San Pablo	60	2.1
Cértegui	20	0.7
Río Quito	44	1.5

Source: DANE – Cuentas Nacionales: PIB por Departamento, 2014. Adapted by INERCO Consultoría Colombia 2016.

In the above table, one can identify that Quibdó is the municipality that has more weight on the economic performance of the department. Moreover, the value added of other municipalities does not exceed 6% of the departmental GDP.

- **Unsatisfied basic needs**

Colombia reports 27.78% of the population in Unsatisfied Basic Needs conditions, and Chocó 79.19%, which it is evidence that the Unsatisfied Basic Needs rate in the municipality is considerably lower than the country's level.

Table 4-7. Unsatisfied Basic Needs Index in Bajo Cauca Region

Municipalities	People UBN		
	Total (%)	Municipal city (%)	Other (%)
Colombia	27.78	19.66	53.51
Chocó	79.19	81.94	76.11

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

It is also evident that all the municipalities of this analysis show the lowest levels of satisfaction of basic needs compared with national and departmental data. It can show that all municipalities, except El Cantón de San Pablo (52.55%), have a rate above 80% of unsatisfied needs, as shown in the following table:

Table 4-8. Unsatisfied Basic Needs Index in upper and middle Atrato sub-region

Municipalities	People UBN		
	Total (%)	Municipal city (%)	Other (%)
Quibdó	89.47	90.46	78.54
Atrato	80.11	97.84	71.26
El cantón del san pablo	52.55	52.87	52.32
Cértégui	87.24	92.85	80.47
Río Quito	98.81	99.38	93.82

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

With relation to the availability and access to utilities, specifically water, the department of Chocó has coverage of 21.7%. On another hand, El Cantón de San Pablo (56.67%) presents a higher coverage level than the other reported in the municipalities of the sub-region. However, in a lower coverage level than in Atrato, with 0.1% (DNP, 2016).

Table 4-9. Aqueduct Coverage in upper and middle Atrato sub-region

Municipalities	Coverage (%)
Quibdó	15.93
Atrato	0.10
El cantón del San Pablo	56.67
Cértégui	0.20
Río Quito	0.80

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.
Adapted by INERCO Consultoría Colombia, 2016.

However, it is found that there is no information related to the quality of water of any municipality of Choco so, the companies that provide this service does not register this in the Single Information System – SIS (Superservicios, 2014).

- Institutionalization

In this section, it is presented information relating to the performance of the different entities and transparency of the institutions in the municipalities of upper and middle Atrato sub-region. For this, the Integral Municipal Performance Index developed by DNP was consulted.

- Integral Municipal Performance

The information reported by the DNP shows no municipality delivers full information and, in general, Chocó is qualified with an average performance (63.3%) (DNP, 2014). Below, the information for the upper and middle Atrato region is presented.

Table 4-10. Integral Performance Indicator 2013 for municipalities of upper and middle Atrato region

Municipalities	Efficacy 2013	Efficiency 2013	Legal Requirements compliance 2013	Fiscal Management 2013*	Integral Performance Indicator 2013	Classification Range
Atrato	87.30	26.38	87.17	52.60	63.40	Medium
Cantón de San Juan	92.13	27.68	57.97	83.34	65.30	Medium
Cértegui	79.40	48.83	95.51	56.37	70.00	Satisfactory
Río Quito	52.38	16.47	96.35	63.77	57.30	Low
Quibdó	28.46	18.81	91.84	82.25	55.50	Low

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal, 2014. Adapted by INERCO Consultoría Colombia, 2016.

In the above table, it is shown that Quibdo is the municipality with the lowest level of performance; while Cértegui presents a satisfactory performance.

5 UPPER, MIDDLE AND LOWER SAN JUAN RIVER

5.1 General Aspects

Situated in the southern part of the Department of Choco, on the Pacific Coast. It covers 15,000 mi², bordered on the north by the municipalities of Istmina and Bajo Baudó, on the east by the municipality of Sipi and the Department of Valle, on the west by the Pacific Ocean, and on the south by the Department of Valle.

5.2 Environmental Characterization

- **Water Resource**

The river San Juan covers an approximate area of 15,000 square kilometers. Framed by the western mountain range and the hills of the Pacific coastline, it originates in the Caramanta mound, in the department of Caldas, at 26,000 meters m.a.s.l. and at an approximate distance of 110 kilometers, the channel descends to 30 meter height in the town of Istmina.

One of the most important rivers of the Colombian Pacific slope and the most full flowing in South America, it originates in the Caramanta mound, and runs 380 km, of which 200 are navigable. Its tributaries include the Condoto, rich in platinum, and the Calima, which runs through Vallecaucano territory nourishing the central hydroelectric plant that bears its name, one of the most important hydroelectric plants in the country.

Condoto River Subbasin

The municipality has little jurisdiction over this river. The River Condoto originates in the foothills of the Tarena Mound, at an altitude no more than 2,000 m.a.s.l. and flows into the San Juan River, forming the Andagoya estuary. It has an approximate area of 680 km², and in length runs 48 km and with oscillating between 14.3-15.80 m.

Opogodó River Subbasin

As in the former, the municipality has little jurisdiction over a small portion of the mouth of the San Juan River. Its waters originate at the foothills of the Western mountain range.

Tamana River Subbasin

Yet another River born from the foothills of the Western mountain range, flowing through the Middle San Juan municipality and the village of San Jeronimo before merging with the San Juan River below the town of Primavera.

Sipí River Subbasin

Originates in the Western mountain range and delivers its waters to the San Juan River, after flowing in the waters of the Cajon River at the height of the Playa Garzón.

It comes from the western mountain and delivers its waters to San Juan River, after collecting the waters of the Cajon River up to Playa Garzón.

Suruco River Subbasin

Originating from the Western mountain range and flowing into the San Juan River, it receives water from El Patio, Coredó, El Boteco, Mojarrita, Valentina, El Salado and La Gloria streams. Its waters flow into the San Juan River, at the height of Boca de Suruco.

Bicordó River Subbasin

Originating at the foothills of the Baudó mountain range, this river flows from west to east into the San Juan River south of the town of Noanamá. During its course, it receives waters from the Pimia and Puadó streams as well as other brooks.

Dipurdú de los Indios River Subbasin

Originating at the western border of the Istmina municipality.

Fujiadó River Subbasin

Originates in the foothills of the Western mountain range. Serves as a border between middle San Juan and Istmina and in its course through the first territory receives waters from the Carbonero and Guapagara streams, among others.

- **Aquifers y aqueduct supply basins**

All of the settlements have some type of water supply, while the municipal capital is provided with pumped and treated water. Copomá, Palestina, Los Perea, Taparal and Pichimá Quebrada depend on a gravity system. The other communities depend on supply tanks for rainwater. Important to note; the only central municipality that supplies treated water is Docordó.

- **Relief and soils**

The classification of the relief in the sub-region of the San Juan is EOT of San Juan, 2000:

Moderate to Low Meadows and Terraces: Corresponds to quaternary deposits of alluvial origin situated along the flows of the principal rivers, forming hydrometric alluvial deposits of clay or silt-clay granulometry.

Banks or Beach Dunes and Espigas: These deposits correspond to sedimentary accumulations whose average size is over medium sand grain. They are transported by ocean waves depositing coarser material on the beach.

Tidal planes and Basins: Are those areas flooded during high tide and on which mangroves develop. These areas are composed of sludge and an abundance of organic material formed by innate mangrove forests that developed in this sector.

Marine Terraces: Superficies de erosión marina producto de la acción del mar sobre las rocas sedimentarias de la Formación Mallorquín, las cuales presentan un relieve bajo y uniforme en el momento de ser sometidas al efecto de las olas.

- **Atmospheric resource**

The average yearly precipitation runs from 7,500 and 7,550 mms per year. It has been estimated that the precipitation in this coastal area diminishes with a gradient close to 170 mm's per kilometer in relation to its distance to the ocean. The temperature oscillates between 24°C and 28°C.

Table 5-1. Climatic distribution

Type	Area	Temperature °C
Very cold, Humid and Per-humid	Upper region of the rives Cucurupí, Copomá and Munguidó	7-15
Cold Humid y Super Humid	Middle region of the rivers Cucurupí, Copomá and Munguidó	11-15
Warm Super Humid	Middle region of the rivers Cucurupí, Copomá and Munguidó	23
Warm Per-humid	Coastal region	23

Source: EOT San Juan, 2010. Adapted by INERCO Consultoría Colombia, 2016.

- **Strategic Ecosystems and areas of environmental protection**

The areas destined to environmental conservation and protection for the sub-region or delta of the river are the Natural National Park (PNN) Tatamá and the Pacific Forrest Reserve (Law 2da/59). Among the municipalities of interest to the ENV/Minning the PNN, The Pacific Forrest Reserve, includes the municipalities of Istmina, Sipí and Nóvita. The PNN of Tatama only includes the municipality of Tado.

Tatamá Natural National Park

The geographic location, the presence of virgin highland (paramo), the excellent state of conservation make the PNN Tatama an area of high scientific interest and a perfect refuge for most of the rich vegetation and animal species. The park is located in the western mountain range. Tributaries originate on this land whose waters low into the Rivers San Juan and Cauca. At the highest points, we find the unique highland *paramo* of Tatama, one of the three *paramos* in Colombia that have not been intervened by man.

The park extends 51,900 ha and was created in 1987.

For the ENV/Minería program's interests, this park encompasses a small portion of the municipality of Tado.

4.3 Socio-economic characterization

In this section principal indicators of a socio-economic component for the municipalities of Condoto, Cantón de San Pablo, Istmina, Nóvita, Tadó y Unión Panamericana will be presented. For this end, secondary official sources of information have been consulted.

- **Demographic processes**

Population Composition

According to the population projections data provided by DANE, in 2015 the population of upper, middle and lower San Juan region, was 76,466 inhabitants, 65.53% of which were located in the municipal capital and only 34.47% lived in the rural area. The most populated municipalities were Tadó (18,906), and Istmina (25,351). The least populated is Nóvita (7,957).

Below, the population distribution to urban and rural level in the municipalities in the lower, middle and upper San Juan sub-region .

Table 5-2 Population Composition by municipal capital

Municipalities and sub-regions	2015 Population			People in municipal capital	People in the rest of the area
Name	Total	Municipal capital	Other	(%)	(%)
Total Dept.	500,093	245,923	254,170	49.18	50.82
Sub-region	76,466	50,109	26,357	65.53	34.47
Condoto	14,660	10,324	4,336	70.42	29.58
Istmina	25,351	20,112	5,239	79.33	20.67
Nóvita	7,957	3,192	4,765	40.12	59.88
Tadó	18,906	12,266	6,640	64.88	35.12
Unión Panamericana	9,592	4,215	5,377	43.94	56.06

Source: DANE: Demografía y Población - Proyecciones de población 2015, 2011. Adapted by INERCO Consultoría Colombia, 2016.

- **Ethnic groups**

The majority of the population of the municipalities analyzed are Afro descendants, with a small percentage of indigenous peoples.

In the upper, middle and lower San Juan sub-region, the population of the afro-descendants is 52,047 people, corresponding to 10.40% out of the total in Chocó and 68.07% of the sub-region inhabitants. On the hand, the indigenous people represent the 3.81% of the sub-region population accounting for 2,912 persons.

Table 5-3. Ethnic groups

Sub-regions and municipalities		Total Dept.	Sub-regional	Condoto	Istmina	Nóvita	Tadó	Unión Panam.
Total		500,093	76,466	14,660	25,351	7,957	18,906	9,592
Ethnic Group	Indigenous	43,991	2,912	31	1,060	232	1,577	12
	ROM	1	0	0	0	0	0	0
	Raizal	41	6	1	3	0	1	1
	Palenquero	0	0	0	0	0	0	0
	Afrocolombian	277,783	52,047	11,463	20,090	3,651	13,386	3,457
None		178,277	21,501	3,165	4,198	4,074	3,942	6,122

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- **Education**

Illiteracy

The highest levels of illiteracy are found in the rural areas of all municipalities, especially in Novita, exceeding the departmental average. Condoto, Istmina Tadó and Unión Panamericana are below the medium departmental average.

Table 5-4. Illiteracy rate

Department/Municipality	Total (%)	Municipal capital (%)	Other (%)
Chocó	28.10	17.00	41.80
Condoto	18.40	14.40	27.90
Istmina	17.97	12.50	36.72
Novita	40.00	24.10	40.00
Tadó	26.10	15.70	46.50
Unión Panamericana	13.71	13.12	14.11

Source: DANE: Demografía y Población – Censo, 2005. Adapted by INERCO Consultoría Colombia, 2016.

- **Armed Conflict**

In Upper, Middle and Lower San Juan region, the presence of armed groups such as columna móvil Libardo García of Frente Arturo Ruíz, fronts 57, 30, 34 and Aurelio Rodríguez FARC EP were reported. The ELN also operates with resistance fronts Cimarron, Manuel Hernandez - El Boche and Ernesto Che Guevara in the upper, middle part of San Juan (Defensoría del Pueblo, 2014). In this area, confrontations take place very often between these groups and those with the police force. Situations in which the population is part of combats consisting in crossed fire between guerilla groups are very often (Unidad para la atención y reparación integral de víctimas, 2014).

People of the region continue to face extortion, occupation of their lands for coca plantations, supplying troops of any of the armed groups that may be the case, of being finger-pointed, collective killings and abductions, burning of goods, possession withholding, restricted transport of goods and food, and forced displacements by other groups with accusations of being auxiliaries (Defensoría del Pueblo, 2014).

The area is a strategic communication corridor in the southeast Antioquia region, the coffee region, and the Pacific Ocean, making it a constant target for conflict among armed groups. Other violent actions present in the region include blockading the river and restricting access for some municipalities creating a heightened food crisis depending on the time of year, since it is fundamentally an extractive economy. Furthermore, displacements and forced re-settlements have been a detriment to the primarily agricultural vocation of the region.

It is evident that 1,283 cases were reported in the region by the end of 2015, accumulating 12.82% of total cases at departmental level (Registro Único de Víctimas, 2016). These cases, mostly affecting afro-descendant communities (Unidad para la atención y reparación integral de víctimas, 2014). Most of these cases occur in Istmina.

Table 5-5. Displacement data in upper, middle and lower San Juan region

Municipalities	2011	2012	2013	2014	2015
Chocó	13,698	19,621	18,717	16,678	10,011
Sub-region	1,119	2,229	1,844	1,822	1,283
Condoto	62	142	155	204	129
Istmina	656	534	782	895	524
Novita	139	152	312	253	214
Tadó	209	1,368	573	439	376
Unión Panamericana	53	33	22	31	40

Source: Registro Único de Víctimas, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- **Economy**

The extraction of minerals (gold, silver, platinum, limestone, tin, nickel, chrome, and copper) and timber falling sustain the principle economy of the region. Other important sectors include agriculture, cattle ranging, both artisan and traditional. The principal crops farmed include plantain, rice, yucca, *chontaduro*, corn, *ñame*, cocoa, breadfruit, pineapple, *borojó*. As for timber forestation, the most exploited species are *abarco*, *lechero*, *chanó*, *algarrobo*, *peine mono y palo perico*. Fishing is aimed and dedicated to the local market. In general, the economy of the region is exclusively extractive of primary resource material, making food security fragile for the communities.

In order to determine the economic importance of each municipality within the department, below, it is presented the relative weight corresponding to the distribution of value added of the department established from indicators. The GDP of the department of Choco is \$ 2,914,000,000 for 2014 (DANE, 2015).

Table 5-6. Relative weight of municipalities of upper, middle and lower San Juan Sub-region

Municipalities	Value added (Billions of pesos)	Municipal relative weight in the departmental GDP (%)
Condoto	103	3.5
Istmina	293	10.1
Nóvita	152	5.2
Tadó	138	4.8
Unión Panamericana	42	1.4

Source: DANE – Cuentas Nacionales: PIB por Departamento, 2014. Adapted by INERCO Consultoría Colombia, 2016.

The added contribution of these municipalities is about 25% of departmental GDP. Istmina is the municipality with the greatest participation in the distribution of departmental GDP.

- **Unsatisfied basic needs**

It is evident that the municipalities of this region have higher unsatisfied basic needs levels than the national data. The municipalities with the highest unsatisfied needs are Istmina and Cértégui with population proportions exceeding 86%.

Table 5-7. Unsatisfied basic needs index in upper, middle and lower San Juan Sub-region

Municipalities	People UBN		
	Total (%)	Municipal capital (%)	Other (%)
Condoto	62.58	65.99	54.41
Istmina	88.08	92.32	73.59
Novita	66.19	53.35	72.80
Tadó	86.86	89.30	82.43
Unión Panamericana	53.39	69.71	43.44

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

With regard to the availability and access to utilities, specifically in relation to water, the department of Choco has a 21.7% coverage. The municipality Unión Panamericana (52.4%) has the highest coverage. For its part, the lower level of coverage is presented in Istmina with 10.71% (DNP, 2016).

Table 5-8. Aqueduct coverage in upper, middle and lower San Juan Sub-region

Municipalities	Coverage (%)
Condoto	38.49
Istmina	10.71
Novita	32.47
Tado	13.13
Unión Panamericana	52.4

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.

Adapted by INERCO Consultoría Colombia, 2016.

On another hand, it is found that there is no information related to the water quality of any municipality of Choco, because the companies that provide this service do not register this information in the Single Information System - SIS (Superservicios, 2014).

- Institutionalization

In this section, it is presented information relating to the performance of the different entities and transparency of the institutions in the municipalities of upper, middle and lower San Juan sub-region. For this, the Integral Municipal Performance Index developed by DNP was consulted.

- Integral Municipal Performance

Below, the information for upper, middle and lower San Juan region is presented. The satisfactory performance of Nóvita stands, while the Unión Panamericana has the lowest level of overall performance (38.5%).

Table 5-9. Integral performance indicator 2013 for municipalities of upper, middle and lower San Juan Region

Municipalities	Efficacy 2013	Efficiency 2013	Legal requirements compliance 2013	Fiscal management 2013*	Integral Performance Indicator 2013	Classification Range
Condoto	91.50	24.78	94.81	63.04	68.6	Medium
Istmina	48.82	31.44	68.45	74.31	55.8	Low
Nóvita	96.30	34.68	79.71	75.49	71.6	Satisfactory
Tadó	95.56	23.60	58.20	74.02	62.8	Medium
Unión Panamericana	30.13	28.95	32.77	61.97	38.5	Low

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal, 2014. Adapted by INERCO Consultoría Colombia, 2016.

6 VALLE DE ABURRÁ REGION

6.1 General Aspects

Valle de Aburrá region is located the south central-south part of the department of Antioquia and includes the municipalities of Barbosa, Barbosa, Copacabana, Bello, Medellín, Itagüí, Envigado, La Estrella, Sabaneta and Caldas. It is located on the Central Andean Mountains and has an area of 1,165.5 km².

It is an area characterized by high levels of population density and urbanization degree, accumulating more than half of the economic activity of the department, being the most representative the services sector.

6.2 Environmental Characterization

- **Water Resource**

Valle de Aburrá region is located in the basin of Medellín, Nechí, Middle Cauca y Middle Magdalena Rivers. Medellín River is considered as main the main tribute because of its extension and its features of dual drainage. This river, rises in the municipality of Caldas to 3,100 m.a.s.l., runs 104 km south-north in this valley, receiving tributaries along its route, from Grande River, and subsequently, kilometers later form the Porce river, which flows into the Nechí river and, finally flows out into the Cauca river.

Medellin River Subbasin

Located in the center of the department of Antioquia, on the central Andean mountain, the basin has an irregular and sloping topography and dendritic drainage network. The area of the basin is 1,251 km², rainfall level oscillating between 1,000 and 2,500 mm/year make of the basin common sources of surface water.

Grande River Subbasin

It originates to an altitude of about 3,000 m.a.s.l. in the municipality of Santa Rosa de Osos and receives the tributary of Chocó River in the village of Aragon. It also integrates páramo waters from the Candelaria creek and its main tributary is the Chico River, which joins to the municipality of Belmira. Crosses the municipality of Donmatías and later comes together in Medellín River in Barbosa.

Porce River Subbasin

It is located on the Central Andean Mountains, covering 5,248 km² of territory in Antioquia. Its main tributary is the Aburrá River, which joins with the Grande River in Puente Gabino to form the Porce River. The topography of the basin is irregular and altitudes vary from 80 to 3,340 m.a.s.l.

Nechí River Subbasin

Located in the Northeast region of Antioquia and comprises 1,290 km². Includes the municipalities of Nechí, El Bagre, Zaragoza and Cauca. It is characterized by its seaworthiness ability and represents the main mean of communication and supply for fishing and gold mining.

- **Aquifers y aqueduct supply basins**

Aburrá Valley has abundant water sources, although not all is for drinking use, and therefore do not have full coverage. It is found that in the region 974.781 inhabitants have potable water, which mostly come from the Grande River Basin and other watersheds.

- **Relief and soils**

Valle de Aburrá has an irregular topography and slope, enclosed by mountains that allowed the formation of various microclimates, waterfalls, forests, sites of outstanding natural beauty and ecological value. This landscape is characterized, among other things, on the hillsides, edges and slopes of the Central Mountains, predominant mountain's edge and steep slopes.

- **Atmospheric resource**

The average temperature in Valle de Aburra is approximately 21.6 °C. The zone is located areas varying between cold and temperate thermal floor, with heights ranging between 1,300 to 2,800 m.a.s.l., with temperatures ranging between 6 °C and 24 °C. It presents temperature decrease in September and October (Idea, 2010). Relative average humidity is 84%.

Table 6-1. Distribution weather in the municipalities of Barbosa and Donmatías

Biotemperature	Rainfall (mm/year)	Altitude (masl)
12°C-18°C	1,001-2,000	1,800-2,800
	2,001-3,000	1,800-2,800
	3,001-7,000	1,800-2,800
18°C-24°C	1,001-2,000	800 – 1,800
	2,001-3,000	800 – 1,800
	3,001-7,000	800 – 1,800

Source: EOT, 1999. Adapted by INERCO Consultoría Colombia, 2016.

- **Strategic Ecosystems and areas of environmental protection**

There are none strategic Ecosystems and areas of environmental protection in Barbosa and Donmatías.

6.3 Socio-economic characterization

In this section, principal indicators of a socio-economic component for the municipalities of Barbosa and Donmatías will be presented. For this end, secondary official sources of information have been consulted.

- **Demographic processes**

Population Composition

According to the population projections data provided by DANE, in 2015 the population of Barbosa and Donmatías, was 72,295 inhabitants, 52.06% of which were located in the municipal capital and 47.94% lived in the rural area. The most populated municipality is Barbosa (50,052), while Donmatías have 22,243 inhabitants.

Below, population distribution to urban and rural level of these municipalities is presented.

Table 6-2 Population Composition by municipal capital

Municipalities and sub-regions	2015 Population			People in municipal capital	People in the rest of the area
Name	Total	Municipal capital	Other	(%)	(%)
Total Dept.	6,456,299	5,050,047	1,406,252	78.22%	21.78%
Sub-región	72,295	37,635	34,660	52.06%	47.94%
Barbosa	50,052	23,000	27,052	45.95%	54.05%
Donmatías	22,243	14,635	7,608	65.80%	34.20%

Source: DANE: Demografía y Población - Proyecciones de población 2015, 2011. Adapted by INERCO Consultoría Colombia, 2016.

- **Ethnic groups**

The majority of the population of the municipalities analyzed are Afro descendants, with a small percentage of indigenous peoples.

In Barbosa and Donmatías, the population of the afro-descendants is 1,694 people, corresponding to 0.292% out of the total in Antioquia, the first accounting the greatest portion at 97.7% of the sub-region inhabitants and the later at 0.3%. On the hand, the indigenous people represent the 0.038% of the total indigenous population in Antioquia.

Table 6-3. Ethnic groups

Sub-regions and municipalities		Total Dept.	Sub-regional	Barbosa	Donmatías
Total		6,456,299	72,295	50,052	22,243
Ethnic Group	Indigenous	28,914	11	2	9
	ROM	75	0	0	0
	Raizal	552	1	1	0
	Palenquero	0	0	0	0
	Afrocolombian	593,174	1,734	1,694	40
None		5,833,584	70,549	48,355	22,194

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- **Education**

Illiteracy

The highest level of illiteracy are those in the rural areas of all municipalities, especially in Barbosa, exceeding the departmental average. Donmatías is rated below the departmental mean value in rural areas. Both Barbosa and Donmatías total illiteracy rates are smaller than the average for Antioquia.

Table 6-4. Illiteracy rate

Department/Municipality	Total (%)	Municipal capital (%)	Other (%)
Antioquia	7,61%	4,07%	3,54%
Barbosa	6,92%	1,93%	4,99%
Donmatías	5,21%	2,49%	2,73%

Source: DANE: Demografía y Población – Censo, 2005. Adapted by INERCO Consultoría Colombia, 2016.

• Armed Conflict

According to the Unit for Victims, the Valle de Aburrá is one of the five areas with higher prevalence of situations that cause forced displacement (Unidad para la atención y reparación integral de víctimas, 2014).

In the Valle de Aburrá region, the presence of illegal armed groups and organizations BACRIM (Los Paisas, Los Urabeños, Águilas Negras and Los Rastrojos), Oficina de Envigado, FARC Fronts 4, 5, 18 and 36 and Compañía Capitán Mauricio ELN are reported (Unidad para la atención y reparación integral de víctimas, 2014).

Having a great variety of natural geographical accidents, this area is highly strategical in terms of the ease to operate, to mobilize and to coordinate logistics of the later illegally armed groups.

In this area, the armed conflict have been affecting the community in different ways, such as confrontations between guerilla groups and those with the army and police force, combats consisting in crossed fire between guerilla groups and other armed cells, terrorist attacks to oil infrastructure (ducts), kidnapping, extortion, and selective shooting among the population of the region (Unidad para la atención y reparación integral de víctimas, 2014).

As evidenced, 119 cases were reported in the region by the end of 2015, accumulating 0.355 % of total cases at departmental level. (Registro Único de Víctimas, 2016). These cases, mostly affection afro-descendant communities (Unidad para la atención y reparación integral de víctimas, 2014). Most of these cases occur in Barbosa.

Table 6-5. Displacement data in Valle de Aburrá sub-region

Municipalities	2011	2012	2013	2014	2015
Antioquia	58117	49248	48574	33553	23555
Sub-region	223	230	195	212	119
Barbosa	169	149	150	175	98
Donmatías	54	81	45	37	21

Source: Registro Único de Víctimas, 2016. Adapted by INERCO Consultoría Colombia, 2016.

- **Economy**

The base of economy in the sub-region is the paper and textile industry. There are other types of economic and industrial activity such as chemical, clothing manufacture, food and wood, as well as ecotourism, porcine and bovine farming. In recent years, authorities have been promoting low scale agriculture development consisting in different types of crops including sugarcane, coffee, yucca, oranges, corn, and *panela*.

In order to determine the economic importance of each municipality within the department, below, it is presented the relative weight corresponding to the distribution of value added of the department established from indicators. The GDP of the department of Antioquia was COP \$ 101,989,000,000,000 for 2014 (DANE, 2015).

Table 6-6. Relative weight of the municipalities of Valle de Aburrá Sub-region

Municipalities	Value added (Billions of pesos)	Municipal relative weight in departmental GDP (%)
Barbosa	665	0,8
Donmatías	279	0,3

Source: DANE – Cuentas Nacionales: PIB por Departamento, 2014. Adapted by INERCO Consultoría Colombia, 2016.

The valued added of these municipalities is approximately 0.92% of departmental GDP. Barbosa is the municipality with the greatest participation in the distribution of departmental GDP.

- **Unsatisfied basic needs**

Colombia reports 27.78% of the population in Unsatisfied Basic Needs conditions, and Antioquia 22.96%. It is evident that both municipalities present unsatisfied basic needs levels

lower than national data. The municipality with the highest unsatisfied basic needs level is Barbosa, with population portion greater to 21.7%.

Table 6-7. Unsatisfied Basic Needs Index in Valle de Aburrá Sub-region

Municipalities	People UBN		
	Total (%)	Municipal capital (%)	Other (%)
Barbosa	21,73	12,29	29,16
Donmatías	18,72	13,75	27,77

Source: DANE – Censo 2005: Necesidades Básicas Insatisfechas, 2008. Adapted by INERCO Consultoría Colombia, 2016.

With relation to the availability and access to utilities, specifically water, it should be noted that the department of Antioquia has coverage of 85.7 %. Both municipalities has a rate of 87.6 %, which is higher than the departmental data (DNP, 2016).

Table 6-8. Aqueduct coverage in Valle de Aburrá Sub-region

Municipalities	Coverage (%)
Barbosa	87.6
Donmatías	87.6

Source: Departamento Nacional de Planeación – Fichas Caracterización Territorial: Municipios, 2016.
Adapted by INERCO Consultoría Colombia, 2016.

On another hand, it is found that there is no information related to the quality of water of any municipality, because the companies that provide this service do not register this information in the Single Information System - SIS (Superservicios, 2014).

- Institutionalization

In this section, the information relating to the performance of the different entities and transparency of the institutions in the municipalities of Barbosa y Donmatías is presented. For this, the Integral Municipal Performance Index developed by DNP was consulted.

- Integral Municipal Performance

Below, the information for these municipalities. The municipality of Barbosa presents an average performance while, Donmatías presents a lower Integral Performance (48.5 %).

Table 6-9. Integral Performance Indicator 2013 for municipalities of Valle de Aburrá

Municipalities	Efficacy 2013	Efficiency 2013	Legal require ments complian ce 2013	Fiscal manage ment 2013*	Integral Performance Indicator 2013	Classification Range
Barbosa	78.1	58.58	32.57	86.4	63.9	Medium
Donmatías	55.03	77.44	61.73	71.27	48.5	Low

Source: Departamento Nacional de Planeación – Desempeño Integral Municipal, 2014. Adapted by INERCO Consultoría Colombia, 2016.

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ANNEX 2. Interviews Conducted

Between April 4th and 7th, 2016, a visit for field data collection was performed in the department of Chocó. During these visit 12 semi-structured interviews were applied to different stakeholders of the Oro Legal program, such as of Mayors, representatives of community councils, producer organizations and a research institution, which were prioritized by the regional Coordination of the Oro Legal Program in Choco. The interviews conducted are in the following table:

Table 1.1 Interviews conducted

Date	Name of Interviewee	Role	Institution	Location ¹
04.04.2016	[REDACTED]	Regional Coordinator Chocó / Consultant	Oro Legal program	Quibdó
04.04.2016	[REDACTED]	President	CORPOCANTÓN - Agricultural association of Cantón de San Pablo	Cantón de San Pablo
04.04.2016	[REDACTED]	Legal representative	COCOGESANP – Major Community Council of Cantón de San Pablo	Cantón de San Pablo
05.04.2016	[REDACTED]	Executive director	CORPOMISAN - Corporation of San Juan Community Councils	Condoto
05.04.2016	[REDACTED]	Legal representative	COCOMACOIRO - Major Community Council of Condoto and Iró	Condoto
06.04.2016	[REDACTED]	Legal representative	COCOMACER - Major Community Council of Cértegui	Cértegui
06.04.2016	[REDACTED]	President	ASOMINA – Mining producers association of Las Ánimas	Unión Panamericana
06.04.2016	[REDACTED]	Legal representative	ASOCASAN - Community Council of San Juan	Tadó
06.04.2016	[REDACTED]	Mayor	Tadó Mayor's office	Tadó
07.04.2016	[REDACTED]	Researcher	IIAP - Institute of Pacific Environmental Research	Quibdó
07.04.2016	[REDACTED]	Legal representative	COCOMASIN - Major Community Council of San Isidro	Quibdó
07.04.2016	[REDACTED]	Legal representative	COCOMAUPA - Major Community Council of Unión Panamericana	Unión Panamericana

Source: ACON team of consultants, 2016.

For the application of interviews, the following letter of introduction was provided by the regional coordination of Oro Legal in Choco. With this letter, the scope of the visits was specified, avoiding risks of expectations or misinterpretations by the visited stakeholders:

¹ All interviews were conducted in the department of Chocó



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Quibdó, Chocó. 5 de abril de 2016.

Señores

CONSEJO COMUNITARIO MAYOR DE CONDOTO E IRÓ

Directivo

E.S.M

Asunto: Presentación Especialista Social Programa Oro Legal

Respetados Sres.,

Como es de su conocimiento, ORO LEGAL es un programa financiado por la Agencia de los Estados Unidos para el Desarrollo Internacional en Colombia (USAID/Colombia), el cual está siendo implementado por Chemonics Internacional, y cuyo objetivo es apoyar los esfuerzos de Colombia, para manejar sosteniblemente los recursos naturales.

En el marco del Programa, venimos trabajando en la formulación de una Evaluación Ambiental, proceso dentro del cual, realizamos una serie de entrevistas a actores claves que tienen incidencia en el área de acción.

Por lo anterior, les presentamos a nuestra Especialista Social SILVIA FERIA, identificada con el número de pasaporte 4771471, y al Ing. DELIO PEREA, Ingeniero Ambiental, identificado con la CC. 1077430198 que se desempeña como Técnico de la oficina Regional Chocó, quienes adelantan las entrevistas anteriormente mencionadas.

Cordialmente,

Coordinadora Regional Chocó
Proyecto Oro Legal

*Recibido
ABRIL 5-/2016
[Firma]*

The scheduled agenda for interviews comprised a total of 5 days and the application of 18 interviews, however, the following several drawbacks impeded to meet this objective:

- Several mayors of Chocó municipalities were in the city of Quibdó on a new local governors summit, and cannot met with the interviewer.
- CODECHOCÓ and IIAP officials were not available during the days of the visit.
- For safety reasons the field visit period was shortened to 4 days, so it was not possible to meet the scheduled agenda.

ANNEX 4. Technologies for treatment of soils contaminated with mercury

El tratamiento o remediación de suelos se realiza implementando diferentes tecnologías como la biorremediación, vitrificación, solidificación/estabilización, electrocinética o confinamiento, entre otras. Cada una de ellas requiere ciertas condiciones mínimas locativas y de operación, las cuales deben evaluarse para seleccionar la más apropiada. A continuación se presenta un resumen de las tecnologías comúnmente utilizadas, obtenido a partir de fuentes secundarias de información, y un análisis de la posible aplicación de estas en el territorio afectado.

Confinamiento

Consiste en la instalación de barreras verticales u horizontales hasta encontrar una capa de material arcilloso impermeable. Cuando esta capa no existe, se debe hacer extracción del agua subterránea ubicada en la parte inferior (confinamiento hidráulico), la cual debe ser tratada para remover posibles contenidos de mercurio (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Entre sus ventajas, se encuentra que presenta bajos costos, pues, no requiere extracción para tratamiento y disposición final de la tierra. Además, permite la aplicación simultánea con otras tecnologías y protege cuerpos de agua subterráneos o superficiales. No obstante, esta tecnología implica que los contaminantes no sean retirados del sitio y requiere realizar monitoreo y seguimiento en el largo plazo al grado y eficiencia de confinamiento (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Para su aplicación en sitios afectados por contaminación causada por la minería ilegal en Antioquia y Chocó, se debe tener en cuenta que esta tecnología conlleva a sobrecostos asociados a la dificultad de acceso a los lugares a descontaminar y la operación de la maquinaria necesaria debido a la irregularidad del suelo, en términos de facilidad de construcción. Igualmente, debe tenerse en cuenta el alto consumo de energía eléctrica (y los costos para garantizar su suministro en regiones apartadas) requerido para la operación de la máquina para la extracción de agua subterránea y el costo del tratamiento posterior del agua.

Solidificación / estabilización y extracción

Tratamiento o in situ ex situ que busca disminuir la movilidad o lixiviación de contaminantes en el suelo, y requiere que la concentración de contaminantes sea menor a 260 mg Hg/Kg de suelo y que el pH se encuentre balanceado para poder garantizar concentraciones finales menores a 0.2 mg Hg/L (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Por lo general, la solidificación es un proceso de encapsulación física y la estabilización se presenta por medio de un conjunto de reacciones químicas para disminuir la solubilidad del contaminante usando sustancias a base de azufre, como sulfuro elemental, tiosulfato, entre otros (EPA, 2007).

Para suelos de baja profundidad, se pueden mezclar los químicos con el suelo con herramientas tradicionales para hacer pozos como taladros y excavadores. Sin embargo, para los de mayor profundidad, es necesario implementar la tecnología Cement deep soil mixing, que consiste en mezclar suelo con lodo y cemento utilizando taladros de alta potencia (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Generalmente no requiere tratamientos adicionales posteriores; sin embargo, de acuerdo a la complejidad de remoción de las sustancias presentes, debe complementarse con la Vitrificación (EPA, 2007).

La viabilidad de aplicación de esta tecnología está determinada por la concentración de contaminantes y el pH de los suelos, los costos de las sustancias necesarias para realizar el tratamiento y el uso de maquinaria, debido a que se puede requerir la excavación en suelos profundos, para lo que es necesario utilizar taladros de alta potencia. Esto a su vez, conlleva al consumo de energía eléctrica y combustibles para el funcionamiento de estos. Igualmente, cuando existen mini lagunas con aguas contaminadas en minas abandonadas, se hace necesario extraer el agua y someterla al tratamiento pertinente. En lugares distantes de centros poblados, se presentarían sobrecostos por las dificultades de acceso y la aplicación de esta tecnología.

Vitrificación

Tratamiento in situ en el que los suelos contaminados son calentados hasta su punto de fusión y posteriormente son enfriados con el objetivo de obtener un sólido químicamente inerte y vidrioso donde los químicos son inmovilizados (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Puede utilizarse en suelos que contengan materia orgánica en concentraciones entre el 7% y el 10% como material de combustión, lo que implica una reducción en la cantidad de energía necesaria para el procedimiento (EPA, 2007). La eficiencia de vitrificación se ve afectada por presencia de arcillas y humedad, esto último implica que aquellos suelos que tengan contenido de humedad mayor al 25%, requieran ser sometidos a un pretratamiento para disminuir el contenido de humedad.

Por otro lado, el mercurio es un contaminante volátil y de baja solubilidad en vidrio, se recomienda que la concentración de mercurio no supere 0.1% (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Teniendo en cuenta que varios municipios de Chocó y Antioquia afectados por la minería ilegal presentan alta humedad relativa y precipitaciones constantes, y que algunos, pueden contener lodos, se generarían sobre costos por la necesidad de disminuir el contenido de humedad de los suelos. Así mismo, se deben considerar los sobrecostos y la facilidad de acceso de elementos de generación de energía eléctrica y el consumo de combustible requerido para las actividades a desarrollar. Sin embargo, en lugares bastante afectados

por el uso de mercurio se podrían encontrar concentraciones de mercurio en el suelo mayores a 0.1%, lo que no permitiría la implementación de esta medida de remediación.

Lavado de suelo y extracción ácida

Tratamiento in situ o ex situ que consiste en la extracción de contaminantes usando una solución de agua con químicos o un extractante orgánico. La remoción se presenta por solubilización, emulsificación o reacciones químicas. Estas últimas se presentan como resultado de un ajuste de pH en el suelo, quelación de contaminantes metálicos o reemplazar cationes tóxicos por no tóxicos (EPA, 2007).

Se espera que tenga altos niveles de efectividad y eficiencia en suelos con bajo contenido de barro y lodos, especialmente en suelos arenosos o limosos, de alta permeabilidad y conductividad hidráulica mayor a 1×10^{-3} cm/s. No es muy efectivo en suelos con altas cargas orgánicas (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Este tratamiento podría presentar elevados sobrecostos asociados a las actividades de tratamiento de las aguas residuales y aguas subterráneas, debido a que éstas se deben reutilizar o descargar a una Planta de Tratamiento de Aguas Residuales – PTAR, que debe incorporar procesos de precipitación, intercambio iónico, intercambio electroquímico, adsorción con carbón activado ultrafiltración u ósmosis inversa.

Por otra parte, se debe incorporar en el análisis de viabilidad económica, los costos de la maquinaria necesaria para la manipulación del suelo y la dificultad de acceso y operación en el lugar determinado. Además, es necesario contemplar la adquisición de sustancias químicas y los requerimientos asociados a esta, como personal preparado para su manipulación, condiciones de almacenamiento y disponibilidad de las mismas.

Tratamiento térmico

Este tratamiento puede realizarse de forma ex situ o in situ, y consiste en un proceso de volatilización de contaminantes como el mercurio a través de energía térmica. No se recomienda la aplicación en suelos con alto contenido de lodos o carga orgánica. La rapidez de tratamiento depende del contenido de humedad en la matriz a tratar y la cantidad y tipos de contaminantes, variando entre meses o años en descontaminar (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Para tratamiento ex situ, la concentración debe ser mayor a 260 mg Hg/ Kg de suelo. El suelo debe secarse, mezclado con arena o libre de detritos (EPA, 2007).

Las aplicaciones in situ se dan en suelos subsuperficiales heterogéneos haciendo uso de pozos o sábanas térmicas. Funciona mejor en suelos arenosos que en suelos de arcillosos y limosos, pues, la materia orgánica y la humedad del suelo impiden el movimiento del calor y vapor (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Requieren el uso de un equipo para el control de emisiones de polvo y contaminantes evaporados como una Unidad APC.

Es importante considerar diferentes limitantes de operación, que podrían generar sobrecostos o impedirían la aplicación de esta tecnología. Entre estas, se pueden considerar costos adicionales o sobrecostos por el uso de la maquinaria necesaria para la remediación. En el caso de la metodología ex situ, se debe contemplar la realización de procedimientos de excavación, extracción y transporte del suelo hasta una instalación que cuente con los equipos necesarios. Por su parte, la aplicación in situ puede afectarse por la heterogeneidad del suelo en cuanto al uso de sábanas, debido a que el terreno afectado muestra forma irregular pronunciada, lo que no garantizaría que la tierra entre en contacto con el suelo apropiadamente. Asimismo, se debe considerar en el estudio de factibilidad el requerimiento energético necesario para la aplicación de calor al suelo a tratar.

Remediación Electrocinética

Tecnología de remediación in situ que consiste en la aplicación de campos eléctricos a través de una matriz de suelo para generar la migración o movimiento de compuestos cargados eléctricamente. Se aplica en suelos arcillosos y permite remover simultáneamente mercurio y otros metales pesados (Roseslato & Ferro, 2014).

Requiere la construcción de pozos que contienen una solución electrolítica, los cuales son permeables y están en contacto hidráulicamente con el suelo. Los contaminantes son solubilizados aplicando soluciones acuosas a base de yodo para generar compuestos iónicos yodo-mercurio. La remoción de contaminantes se da por medio de la extracción de los electrolitos en los pozos (Roseslato & Ferro, 2014).

Su eficiencia depende de condiciones tales como la concentración del contaminante, porosidad y textura del suelo, y potencial iónico del electrolito.

Los limitantes de aplicación de esta tecnología consisten en la construcción de pozos para albergar los cátodos y la solución electrolítica, la disponibilidad de la maquinaria a utilizar sus costos logísticos (alquiler y transporte) y operativos (combustible). Por otra parte, la solución electrolítica requerida para el funcionamiento de la tecnología, esta ser adquirida cumpliendo unos requisitos de operación que garanticen la remoción deseada, y de igual forma, debe contemplarse el costo de transporte y proceso de tratamiento final de dicha solución. Finalmente, se deben contemplar los costos asociados al consumo de energía para la generación del campo eléctrico requerido.

Biorremediación

Existen evidencias que prueban eficiencia en el tratamiento; sin embargo, no existe total certeza de los mecanismos que aplican. Básicamente, estos consisten en la conversión del mercurio en especies retenidas en biomasa o de mayor facilidad de remoción por tecnologías complementarias (Covarrubias, García Berumen, & Peña Cabriales, 2015). Entre estos se encuentran (EPA, 2007). A continuación, se muestran algunos tipos de bioremediación:

- Biosorción: Hongos filamentosos y Microorganismos (Rhizopus)
- Bioprecipitación (reducción biológica): Bacterias sulfato reductoras (BSR).

- Biolixiviación: acidificación del medio por movilización de protones. Bacterias quimiolitotróficas y acidófilas (*Thiobacillus thiooxidans*, *T. ferrooxidans* y *Leptospirillum ferrooxidans*)
- Biovolatilización: metilación de metales pesados y metaloides (Hg, As, Se). En el caso del mercurio, se cuenta con la enzima mercurio reductasa, reportada en especies como *Pseudomonas putida*, *Escherichia coli* y *Deinococcus radiodurans*, y en generos como *Pseudomonas*, *Acinetobacter*, *Bacillus*, *Shewanella*, *Saphylococcus* y *Stenotrophomonas*.

Como primera instancia, es necesario realizar una investigación en detalle de la vegetación nativa y presente en las zonas afectadas, con el fin de determinar sus características de crecimiento, así como su capacidad de retención, depuración, precipitación y volatilización de contaminantes, especialmente el mercurio. Posteriormente, se debe determinar la mejor estrategia de remediación, a través de la realización de ensayos o pruebas piloto en laboratorio, para probar la supervivencia y capacidad de absorción de mercurio en condiciones similares a las de las zonas a tratar. Posteriormente, se deben tener en cuenta los costos de mano de obra y equipos necesarios para la siembra y mantenimiento de la plantación. Finalmente, se deben estimar los costos del tratamiento pertinente o de disposición final de las plantas como residuo peligroso, en caso de ser necesario.

Fitorremediación

Uso de plantas para remover mercurio por medio de procesos de Fitoextracción, Fitoestabilización y Fitovolatilización.

En suelos contaminados con metales pesados, la fitoextracción es más popular. Se puede potencializar con Bacterias y Hongos que intervienen por medio de procesos de metilación, sorción, lixiviación y precipitación, y la producción de ciertos metabolitos (sideróforos, metalotioneínas, fitoquelatinas y expolisacáridos). Minimiza la perturbación del suelo y ayuda a la recuperación del entorno debido a su alto valor estético. Puede absorber varios contaminantes al mismo tiempo y puede abarcar amplias zonas. Aplica para zonas no profundas con bajas concentraciones de contaminantes (He, Gao, Pierce, Strong, Wang, & Liang, 2015).

Actualmente, se encuentra en investigación y desarrollo, pues la aplicación de este tratamiento depende de diferentes factores que varían en cada caso, como lo son las condiciones medio ambientales de la zona. Las plantas removidas deben ser tratadas para la remoción y correcta disposición final de los materiales acumulados (He, Gao, Pierce, Strong, Wang, & Liang, 2015). Con frecuencia se ha encontrado la introducción de especies no nativas e invasivas para la remediación de algún lugar (Ayala Mosquera, Mosquera Pino, & Murillo Moreno, 2008).

Finalmente, es necesario llevar un control y seguimiento a medidas de cerramiento o aislamiento de las plantas, pues los animales domésticos o silvestres pueden alimentarse de las plantas contaminadas.

A pesar de ser la alternativa más costo-eficiente, es necesario considerar los costos asociados al tratamiento y/o disposición final del material vegetal contaminado, cerramiento o aislamiento de la plantación. Sin embargo, las ventajas asociadas pueden exceder estos costos, pues se presenta un proceso de remediación en el que los campesinos se involucran directamente en la remoción de la contaminación y recuperación paisajística del terreno y se apropian de las actividades a realizar.

Nanotecnología

Procedimiento que emplea nanopartículas de sulfuro de yodo que son inyectadas en el suelo contaminado para inmovilizar el mercurio, ya sea por procesos de intercambio iónico o de adsorción. Se encuentra en pruebas preliminares de laboratorio y los compuestos a utilizar no deben ser tóxicos y facilitar la preparación in situ. Su aplicación abarca superficies y suelos profundos para la remoción de mercurio elemental y mercurio mercúrico (He, Gao, Pierce, Strong, Wang, & Liang, 2015). No requiere grandes inversiones económicas, ni implica grandes consumos de energía.

Existe alto riesgo asociado al uso de nanopartículas debido a la incertidumbre existente referente al impacto sobre la salud y seguridad. Además, requiere de personal especializado para estas aplicaciones. Sin embargo, debido a que no ha sido desarrollada totalmente, no se recomienda la aplicación de esta tecnología en los terrenos afectados por la minería en Chocó y Antioquia.

En la siguiente tabla, se resumen los aspectos más importantes de cada tecnología, incluyendo los costos:

Fuente	Matriz	Tecnología	In situ / ex situ	Aplicación	Condiciones operacionales	Tratamiento complementario	Observaciones	Costo
Feng He & Jie Gao & Eric Pierce & P. J. Strong & Hailong Wang & Liyuan Liang	Suelo	Confinamiento	<i>In situ</i>	<ul style="list-style-type: none"> ▪ Instalación de barreras físicas en la zona afectada para evitar la movilización del mercurio como mantos, paredes, cortinas, entre otras. ▪ Las estrategias pueden ser cubrimiento de superficies, confinamiento con barreras verticales u horizontales. <p><u>Cubrimiento:</u></p> <ul style="list-style-type: none"> ▪ Consiste en ubicar un sellamiento en el sitio contaminado con una capa superficial para prevenir la infiltración de aguas lluvias y emisiones de polvo y gas. ▪ Puede ser hecha de arcillas compactadas, suelos naturales mezclados con estabilizadores o bentonita, o membranas geosintéticas de baja permeabilidad. <p><u>Barreras horizontales y verticales:</u></p> <ul style="list-style-type: none"> ▪ Elementos utilizados para impedir el movimiento horizontal y vertical del contaminante. ▪ Para las barreras verticales, se pueden utilizar muros pantalla fabricados en concreto o sellamiento o cortinas de geomembranas ▪ Las barreras horizontales todavía se encuentran en proceso de investigación para su aplicación. 	<p><u>Barreras horizontales y verticales:</u></p> <ul style="list-style-type: none"> ▪ Se instalan las barreras verticales hasta encontrar una capa de material arcilloso impermeable, en caso de no ser posible se debe hacer extracción del agua subterránea de la parte inferior (confinamiento hidráulico). 	El agua subterránea extraída debe ser tratada para remover posibles contenidos de mercurio.	<p>Ventajas:</p> <ul style="list-style-type: none"> ▪ Bajos costos, pues no requiere excavar y disponer la tierra. ▪ Se puede aplicar junto con otras tecnologías. ▪ Protege cuerpos de agua subterráneos o superficiales. <p>Desventajas:</p> <ul style="list-style-type: none"> ▪ Los contaminantes permanecen en el sitio. ▪ Se debe realizar monitoreo y seguimiento en el largo plazo de la estructura de confinamiento. 	<p><u>Barrera Vertical:</u></p> <p>\$53,82 - 161,46 / m² (\$5 - 15 /ft²)</p>
EPA	Suelo	Solidificación / estabilización y extracción	<i>In situ o ex situ</i>	<ul style="list-style-type: none"> ▪ Se usan para disminuir la movilidad o lixiviación de contaminantes en el suelo. ▪ Para tratamiento ex situ, la concentración debe ser menor a 260 mg Hg/ Kg de suelo y debe garantizar concentraciones finales 	<p><u>Estabilización:</u></p> <ul style="list-style-type: none"> ▪ Para suelos de baja profundidad, se pueden mezclar los químicos con el suelo con herramientas tradicionales para hacer pozos como taladros y excavadores, sin embargo, para los de mayor profundidad, es necesario 	Generalmente no requiere; sin embargo, de acuerdo a la complejidad de remoción de las sustancias		En promedio \$253,74 / m ³

Fuente	Matriz	Tecnología	In situ / ex situ	Aplicación	Condiciones operacionales	Tratamiento complementario	Observaciones	Costo
				menores a 0.2 mg Hg / L ▪ Aplica para cualquier tipo de suelo. ▪ Solidificación: Encapsulación física ▪ Estabilización: Reacciones químicas para disminuir la solubilidad del contaminante usando sustancias a base de azufre, como sulfuro elemental, tiosulfato, entre otros.	implementar la tecnología Cement deep soil mixing, que consiste en mezclar suelo con lodo y cemento utilizando taladros de alta potencia. ▪ Requiere que se balancee el pH	presentes, debe complementarse con vitrificación.		
EPA Feng He & Jie Gao & Eric Pierce & P. J. Strong & Hailong Wang & Liyuan Liang	Suelo	Vitrificación	<i>In situ</i>	▪ Los suelos contaminados son calentados hasta su punto de fusión y posteriormente se enfrían con el objetivo de obtener un sólido químicamente inerte y vidrioso donde los químicos son inmovilizados. ▪ Utiliza energía térmica ▪ Puede utilizarse en sólidos que contengan materia orgánica como material de combustión, lo que implica una reducción en la cantidad de energía necesaria para el procedimiento.	▪ No aplica para suelos con contenido orgánico mayor a 7%. ▪ Eficiencia afectada por presencia de arcillas y humedad. ▪ Suelos que tengan contenido de humedad mayor al 25%, requieren pretratamiento. ▪ Debido a que el mercurio es un contaminante volátil y de baja solubilidad en vidrio, se recomienda que la concentración de mercurio no supere 0.1%			\$349,23/m³
EPA Feng He & Jie Gao & Eric Pierce & P. J. Strong & Hailong Wang & Liyuan Liang	Suelo	Lavado de suelo y extracción ácida	<i>In situ - Ex situ</i>	▪ Extracción de contaminantes usando una solución de agua con químicos o un compuesto orgánico. ▪ La remoción se presenta por solubilización, emulsificación o reacciones químicas. Estas últimas se presentan como resultado de ajustes de pH en el suelo, quelación de contaminantes metálicos o reemplazar cationes tóxicos por no tóxicos. ▪ Preferiblemente utilizar en suelos con bajo contenido de barro y lodos. ▪ No es muy efectivo en suelos con altas cargas orgánicas, pues este factor interfiere con la	Funciona mejor en suelos arenosos o limosos, de alta permeabilidad, conductividad hidráulica $> 1 \times 10^{-3}$ cm/s	▪ Las aguas residuales y aguas subterráneas recuperadas deben ser sometidas a un tratamiento previo antes de ser reutilizadas o descargadas a las PTAR. ▪ Se recomienda que la PTAR soporte procesos de precipitación, intercambio iónico, intercambio electroquímico, adsorción con		\$78,48 - 170,03/m³

Fuente	Matriz	Tecnología	In situ / ex situ	Aplicación	Condiciones operacionales	Tratamiento complementario	Observaciones	Costo
				remoción del contaminante. ▪ Se utilizan agentes químicos como: ácidos orgánicos e inorgánicos, bases, solventes orgánicos solubles en agua, metanol o agentes complejante de metales.		carbón activado ultrafiltración u ósmosis reversa		
EPA	Suelo	Tratamiento térmico	Ex situ	<ul style="list-style-type: none"> ▪ Desorción o retorta térmica para residuos industriales o médicos que contengan mercurio. ▪ No se recomienda aplicarlo en suelos con alto contenido de lodos o carga orgánica. ▪ Para tratamiento ex situ, la concentración debe ser mayor a 260 mg Hg/ Kg de suelo. 	<ul style="list-style-type: none"> ▪ El suelo debe secarse, mezclado con arena o libre de detritos. ▪ Equipo para control de emisiones de polvo y contaminantes evaporados ▪ Tratamiento rápido, dependiendo de las condiciones (húmedo o seco) del suelo y la cantidad de contaminantes, puede tomar meses o años en descontaminar. 	Unidad APC para captura de gases con contenido de sustancias contaminantes.		
Feng He & Jie Gao & Eric Pierce & P. J. Strong & Hailong Wang & Liyuan Liang	Suelo		In situ	<ul style="list-style-type: none"> ▪ Desorción o retorta térmica in situ para residuos industriales o médicos que contengan mercurio. ▪ No se recomienda aplicarlo en suelos con alto contenido de lodos o carga orgánica. ▪ Utiliza una carga eléctrica que pasa por elementos de calefacción, puede ser por pozos o por sábanas térmicas (contaminación no muy profunda). 	<ul style="list-style-type: none"> ▪ Funciona en suelos subsuperficiales heterogéneos debido a que la conductividad térmica no es muy variable. ▪ Funciona mejor en suelos arenosos que en suelos de arcillosos y limosos, pues, la materia orgánica y la humedad del suelo actúan como superficies que impiden el movimiento del calor y vapor. ▪ El suelo debe secarse y ser mezclado con arena con el objetivo de que se encuentre libre de detritos. ▪ Requiere de un equipo adicional para el control de emisiones de polvo y contaminantes evaporados. ▪ Tratamiento rápido, dependiendo de las condiciones (húmedas o secas) del suelo y la cantidad de contaminantes, puede tomar meses o años en descontaminar. 	Se puede realizar tratamiento simultáneo con un Soil Vapor Extraction en suelos subsuperficiales		\$50 - 250 /ton
Davide Rosestolato, Roberto Bagatin, Sergio Ferro (2014)	Suelo	Remediación Electrocinética	In situ	<ul style="list-style-type: none"> ▪ Aplicación de campos eléctricos a través de una matriz de suelo para generar la migración o movimiento de compuestos cargados eléctricamente. ▪ Comprende cuatro (4) etapas: - Electromigración: Transporte de las especies químicas cargadas en 	<ul style="list-style-type: none"> ▪ Requiere la construcción de pozos para contener una solución electrolítica, los cuales son permeables y están en contacto hidráulicamente con el suelo. ▪ Los contaminantes son solubilizados aplicando soluciones acuosas a base de yodo para generar compuestos iónicos yodo-mercurio. 	No requiere		\$26,16 - 294,30 /m ³

Fuente	Matriz	Tecnología	In situ / ex situ	Aplicación	Condiciones operacionales	Tratamiento complementario	Observaciones	Costo
				el fluido a través de los poros. - Electroósmosis: Transporte de fluido a través de los poros - Electroforesis: Movimiento de partículas cargadas - Electrólisis: Reacción química asociada a la corriente eléctrica. ▪ Se aplica en suelos arcillosos ▪ Puede remover simultáneamente mercurio y otros metales pesados.	▪ Depende de las siguientes condiciones: concentración del contaminante, porosidad y textura del suelo, y potencial iónico del electrolito. ▪ La remoción de contaminantes se da por medio de la extracción de los electrolitos en los pozos. ▪ Funciona mejor en suelos arcillosos y limosos que en arenosos o grava.			
EPA, UPME	Agua	Precipitación/ Coprecipitación	In situ	Se afecta fácilmente por características del agua como dureza, pH, agentes complejantes, iones metálicos o presencia y concentración de más especies de metales pesados.	▪ Control sobre ligandos orgánicos y complejantes reactivos. ▪ Se puede utilizar el reactivo Sulfuro de Sodio (NaHS) ▪ Concentración del efluente puede ser menor a 0,01 ppm	Puede completarse con la Adsorción	▪ Requiere personal capacitado y con experiencia suficiente. ▪ Altos costos para pequeñas superficies	\$4,50 - 10,57 /m ³
EPA, UPME	Agua	Adsorción	In situ	▪ Se puede ver afectada por la presencia de más metales pesados o sustancias contaminantes. ▪ Suele utilizarse cuando el agua está contaminada únicamente con mercurio para sistemas relativamente pequeños. ▪ Puede utilizarse como tratamiento complementario a otras tecnologías utilizadas.	▪ Se recomienda utilizar biomateriales como Carbón activado. ▪ Se recomienda realizar pretratamiento previo del biomaterial para reducir lixiviación de sustancias no deseadas.	No requiere	▪ Recomendado para tratar sistemas o áreas pequeñas. ▪ El personal requerido depende de la complejidad y tamaño del suelo a remediar.	Los costos dependen del caudal a tratar y los contaminantes presentes en el agua. Para un caudal de 0.4X10 ⁶ L/día, se estima costos entre \$0,32 - \$1,70 / 1000 L
EPA	Agua	Filtración por membranas	In situ	Efectivo para el tratamiento de mercurio, sin embargo, no se recomienda debido a altos costos y su eficiencia se compromete en presencia de contaminantes adicionales y características del agua (sólidos suspendidos, compuestos orgánicos, coloides, entre otros).		No requiere		
EPA, Sergio Abraham Covarrubias*,	Agua / suelo	Biorremediación	In situ o ex situ	▪ Existen evidencias que prueban eficiencia en el tratamiento; sin embargo, no existe total certeza	Para la fitorremediación en suelos contaminados con metales pesados, la fitoextracción es la más popular. Se	Precipitación o adsorción		

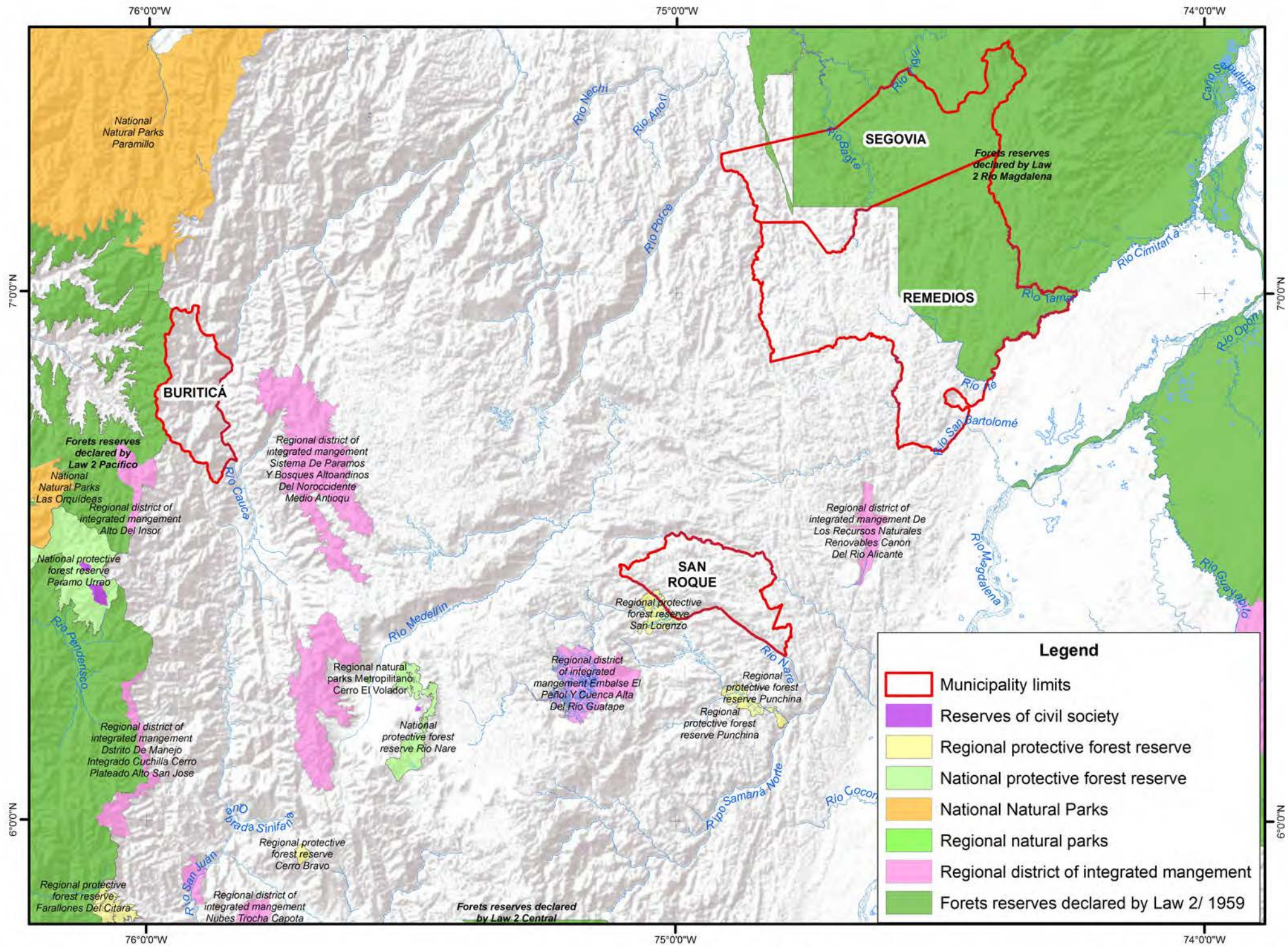
Fuente	Matriz	Tecnología	In situ / ex situ	Aplicación	Condiciones operacionales	Tratamiento complementario	Observaciones	Costo
José Abraham García Berumen*, Juan José Peña Cabriales*				de los mecanismos que aplican. ▪ Básicamente, estos consisten en la conversión del mercurio en especies retenidas en biomasa o de mayor facilidad de remoción utilizando tecnologías complementarias. Algunos ejemplos son: • Biosorción • Bioprecipitación • Biolixiviación • Biovolatilización	puede potencializar con Bacterias y Hongos por medio de procesos de metilación, sorción, lixiviación y precipitación, y la producción de ciertos metabolitos (sideróforos, metalotioneínas, fitoquelatinas y expolisacáridos)			
Ayala H, Murillo W, Mosquera J. (REVISTA BIOETNIA)	Suelo		<i>In situ</i>	Evaluación de la adaptabilidad de la acacia (<i>Acacia mangium</i> Wild) y bija (<i>Bixa Orellana</i>) en áreas degradadas por la actividad minera aluvial en el Chocó biogeográfico, Condoto, Chocó, Colombia.	▪ Pruebas de adaptación a suelos contaminados a cinco (5) especies. Presenta los hallazgos frente a dos especies: <i>Acacia mangium</i> Wild y <i>Bixa Orellana</i> . ▪ Corregimiento La Hilaria (5°06'01"N, 76°32'44"E)			
Adolfo D. Arenas, Lué-Merú Marcó y Gosmyr Torres	Agua	Biorremediación	<i>In situ</i>	Evaluación de la planta <i>Lemna Minor</i> como biorremediadora de aguas contaminadas con mercurio	▪ La planta muestra un proceso de adaptación y tolerancia para concentración inicial de mercurio igual a 0,133 mg/L ▪ La planta muestra eficiencia de remoción de 30% y por tanto, se considera efectiva en la remoción de mercurio. ▪ La concentración de mercurio al final de experimento es menor que al principio, y de acuerdo al balance de masas puede afirmarse que existen pérdidas por evaporación, fitovolatilización y precipitación, ▪ La máxima eficiencia se presenta durante los primeros 6 días.			
Feng He & Jie Gao & Eric Pierce & P. J. Strong & Hailong Wang & Liyuan Liang	Suelo	Fitorremediación	<i>In situ</i>	In situ remediation technologies for mercury-contaminated soil	▪ Utiliza plantas para remover mercurio por medio de fitoextracción, fitoestabilización y fitovolatilización. ▪ Se encuentra en investigación y desarrollo. ▪ Minimiza la perturbación del suelo y ayuda a la recuperación del entorno, altamente aceptada por el público en general por su alto valor estético. ▪ Puede atender varios contaminantes	Las plantas removidas deben ser tratadas para la remoción de los materiales acumulados.	▪ Con frecuencia se ha encontrado la introducción de especies no nativas e invasivas para la remediación de algún lugar. ▪ Animales silvestres pueden alimentarse de las	\$48,40 - 202,73/m³

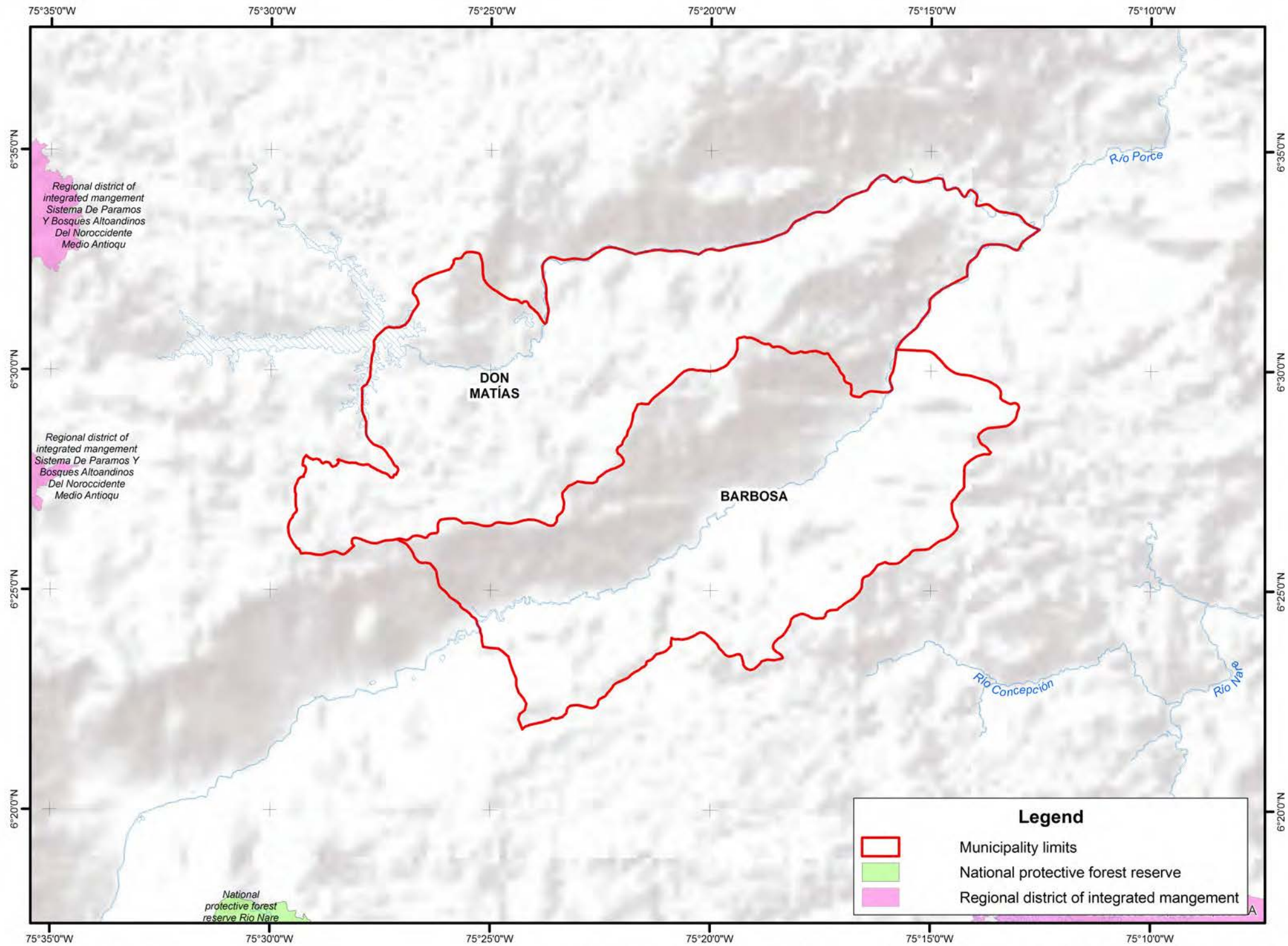
Fuente	Matriz	Tecnología	In situ / ex situ	Aplicación	Condiciones operacionales	Tratamiento complementario	Observaciones	Costo
					al mismo tiempo y abarca amplias zonas. ▪ Aplica a zonas no profundas con bajas concentraciones de contaminantes ▪ Es bastante costo-efectiva ▪ Depende de las condiciones medio ambientales de la zona		plantas contaminadas.	
Feng He & Jie Gao & Eric Pierce & P. J. Strong & Hailong Wang & Liyuan Liang	Suelo	Nanotecnología	<i>In situ</i>	In situ remediation technologies for mercury-contaminated soil	▪ Emplea nanopartículas de sulfuro de yodo que son inyectadas en el suelo contaminado para inmovilizar el mercurio ya sea por intercambio iónico o adsorción. ▪ Se encuentra en pruebas de laboratorio en pruebas preliminares. ▪ Los compuestos a utilizar no son tóxicos. ▪ La solución puede prepararse in situ. ▪ No requiere grandes inversiones económicas, ni requiere mucha energía. ▪ Se puede aplicar a superficies y suelos profundos para remover mercurio elemental y mercurio mercúrico	No reporta	Existe alto riesgo asociado al uso de nano partículas debido a la incertidumbre existente referente al impacto sobre la salud y seguridad.	Costo del químico: \$1,47/m ³

Source: ACON team of consultants, 2016.

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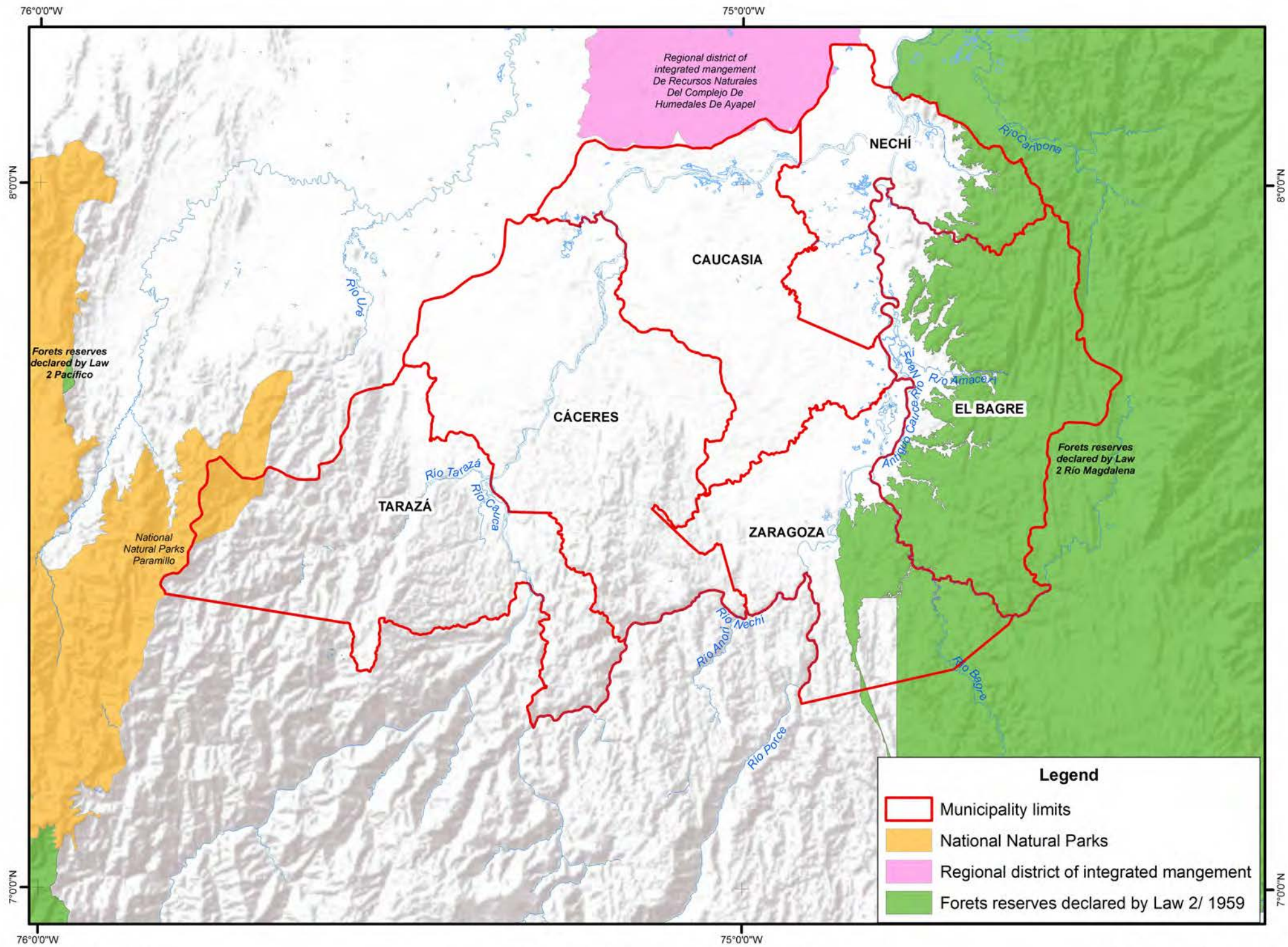


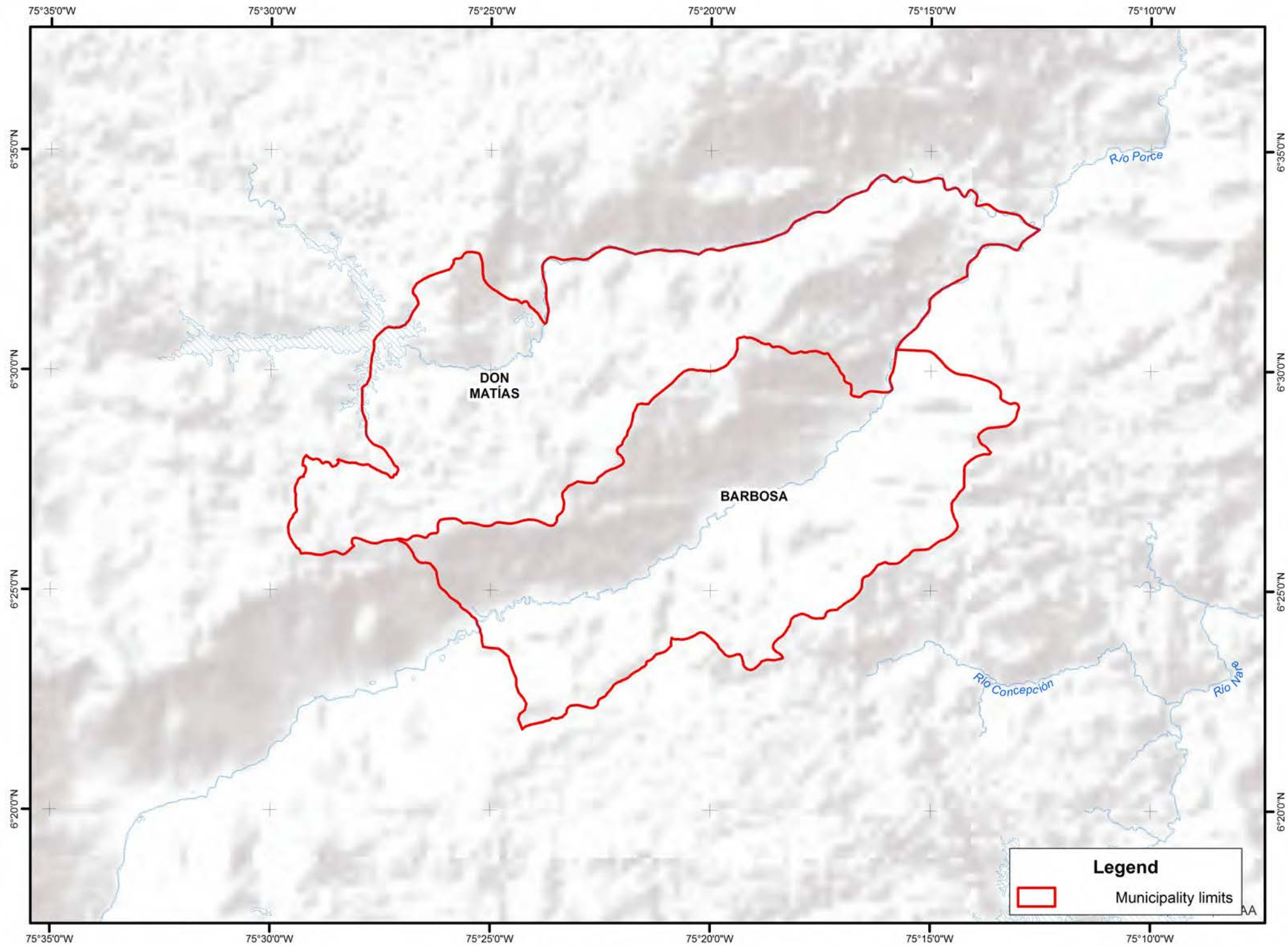


Scale 1:200.000

Source: National Natural Parks of Colombia

Northeast and Buriticá Western

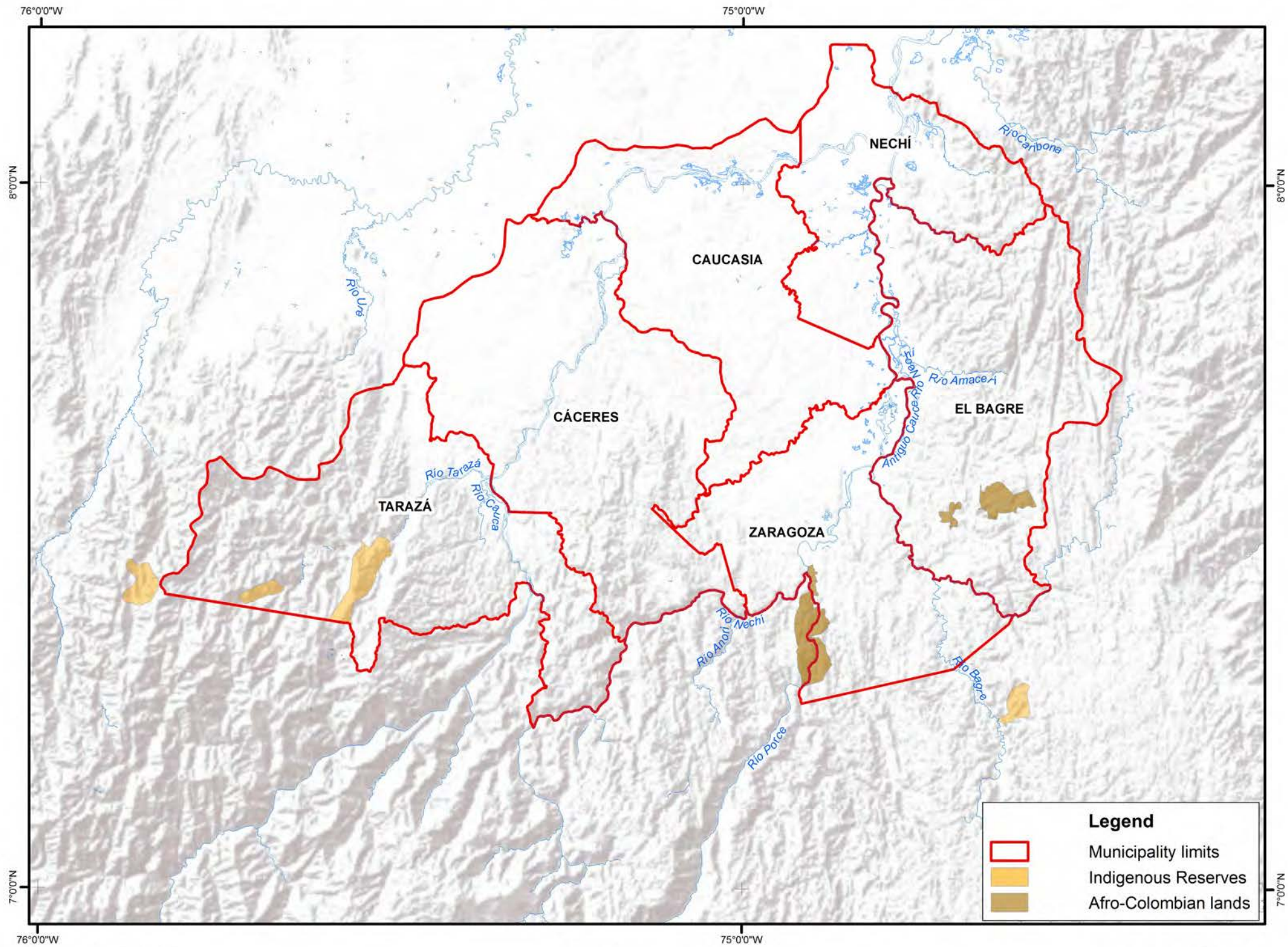




Scale 1:200.000

Source: Ministry of Interior

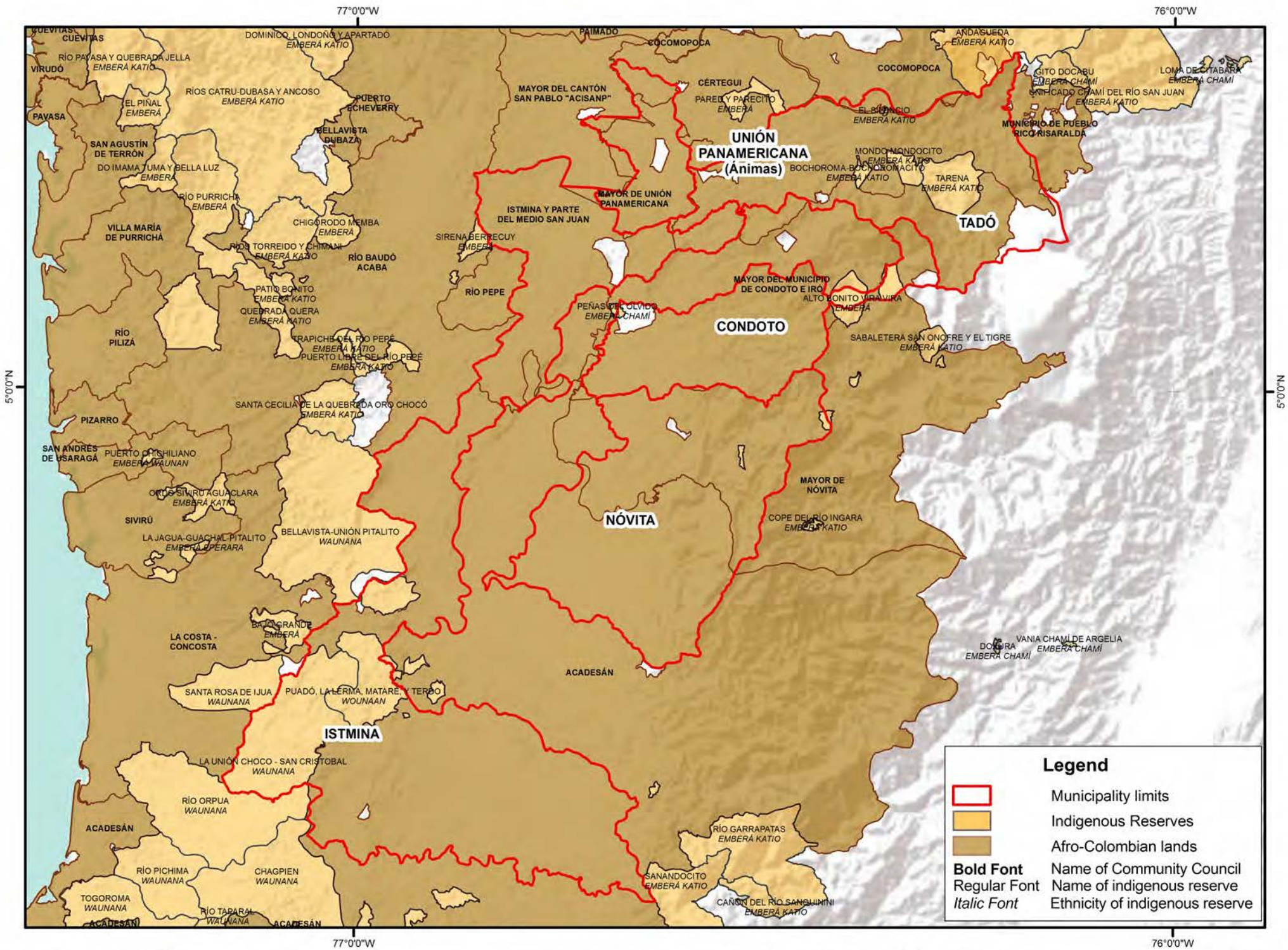
Northeast and Buriticá Western



Scale 1:750.000

Source: Ministry of Interior

Lower Cauca



Scale 1:650.000

Source: Ministry of Interior

Lower, Middle and Upper San Juan River